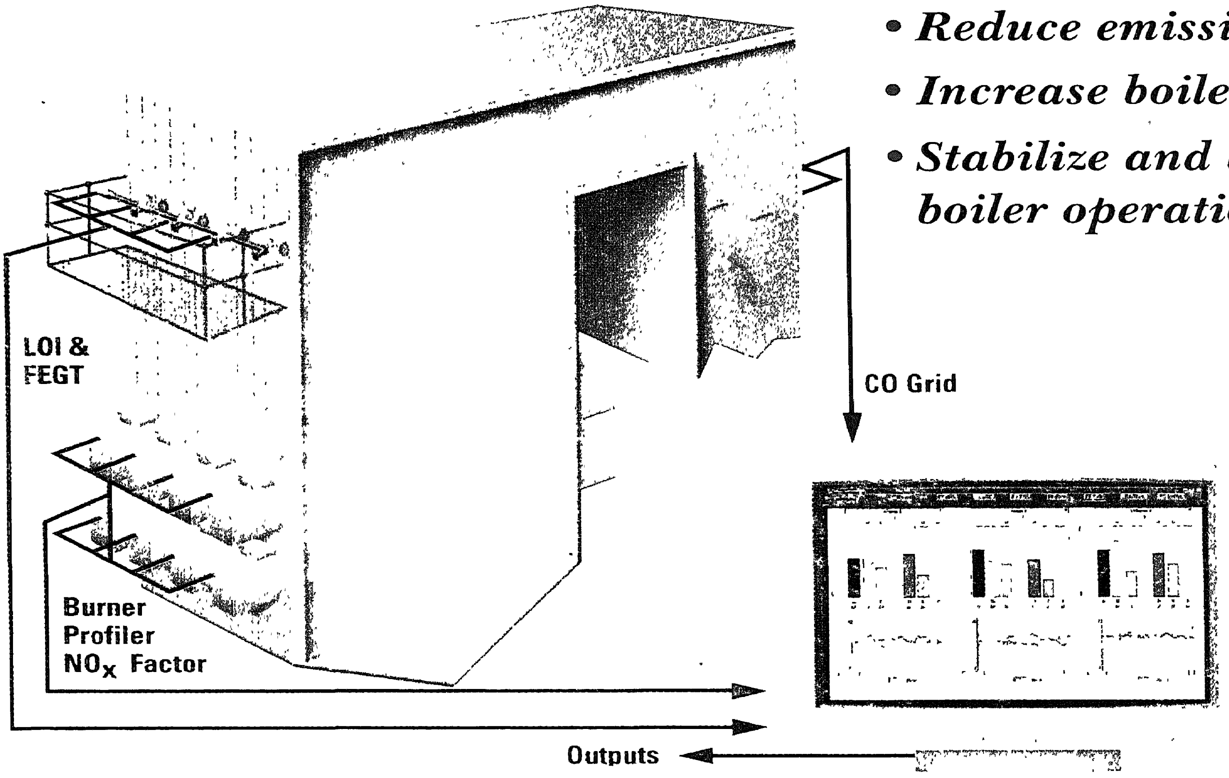
Optimize Air Quality and Boiler Efficiency with MK Combustion Optimization Systems

Our continuous multi-point monitoring systems track key combustion parameters and help you

- ***Reduce emissions***
- ***Increase boiler efficiency***
- ***Stabilize and balance boiler operation***



GE Power Systems

A Division of GE Power Controls
India Private Limited
AIFACS Building, 1 Rafi Marg
New Delhi - 110 011
Tel 91 11 335 5800, 335 5880,
Fax 91 11 335 5955
Email neeraj kaul@geind ge com

gepower.com

N·E·G MICON
For a Powerful Future

What makes us different...

Life time service back up

Highest market share world wide

Continuous technology update

a 100% subsidiary of NEG-Micon

Professionally managed organisation

ISO-9002 certified for Manufacturing & Servicing

Better.Purer.Economical.Source of Energy.

Higher generation-Lower investment per MW

100% lightning protection

Scientific modelling for micrositing

Largest capacity turbines in the country

Lowest reactive power consumption

computerised monitoring and controlling system

With 9200 installations totalling 3175 MW world wide spreadover 40 countries, NEG-Micon today is the world's largest and preferred supplier, an icon in the wind industry. Asian Wind Turbines Pvt.Ltd. is following the foot prints of its parent and marking its presence in the Indian market by focussing on customer needs both for product and service. AWT has now brought India a step forward in the Global arena of wind energy installing the country's first 750 kW WTG's for Dalmia Cements . Savitha Chemicals . Rajasthan State Power Corporation Ltd., . Jayakrishna Flour Mills . Precot Mills Ltd. . Windia Power Ltd. . TNPL Ltd. . Cape Flour Mills. . Nuziveedu Seeds Ltd. . Weizmann Ltd. . Kovilpatti Lakshmi Flour Mills Ltd. . Non - Conventional Energy Development Corporation of Andhra Pradesh Ltd. These installations stand tall as a testimony of our exemplary performance.

If you are considering a wind energy project or just an investment option, give AWT a call ....

ASIAN WIND TURBINES (PVT) LTD.
4/262,Old Mahabalipuram Road,Kandanchavadi,Chennai 600 096. India
Tel : +91 44 4926278,4929562,4480183 Fax : +91 44 4925619
Email : sai@india.neg-micon.com Visit us at : www.neg-micon.dk
(A 100% subsidiary of N·E·G MICON Denmark*)*

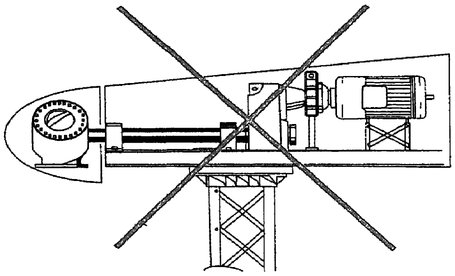
STAGG

Technology Upgradation in Reality
Fully "Type Tested" by Germanischer Lloyd

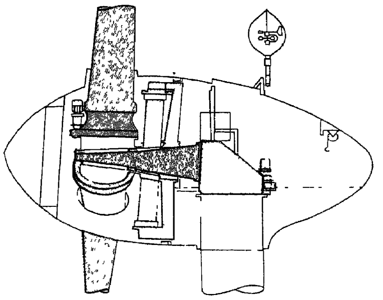
From a Conventional "Wind-mill" having
Gearbox, Asynchronous Generator,
Lattice Tower etc.

To a "Wind Energy Convertor" using
Gearless design, Synchronous Generator, etc.

230 kW & 600 kW



A Germanischer Lloyd ISO 9002 certified company



" The Conventional Design "

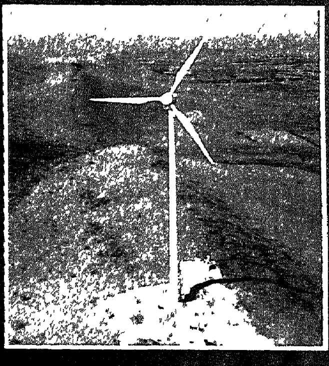
" The Improved Gearless Design "

Few of the Unique Features of Upgraded Technology

- "Gearless: Design
- Stepless Variable Speed
- Continuous Variable Pitching
- "Synchronous" Generator with AC-DC-AC Conversion which is Grid-friendly.
- Three independent "Aerodynamic" brakes
- Slow speed operation
- Steel Tubular Tower
- Allowing Oscilation due to wind pressure
- Lightning protection for blades also

Which offer the following advantages:

- Minimum wear & tear
- Maximum energy capture from Wind
- Unity Power Factor at all times
- Negligible drawl of reactive power from the grid and can supply reactive power to the grid
- No Capacitors required for Power Factor correction
- No voltage peaks
- No mechanical brakes
- Generation starts at lowest speed of 2.5 m/sec



BSES Ltd., at site Jogimatti in Karnataka

ENERCON
INDIA

ENERCON (INDIA) LIMITED
Kolsite House, Plot No. 31, Shah Industrial Estate,
Veera Desai Road, Andheri (West), Mumbai - 400 053
Tel : 91 (22) 636 48 48 ● Fax : 91 (22) 631 51 53
E-mail : mktg@mumbai.enercon-india.com

TEDDY 2001/02

TERI's Governing Council

CHAIRMAN

Dr A Ramachandran
Former Under-Secretary-General
United Nations
3 Crescent Road
High Grounds
Bangalore – 560 001

MEMBERS

Prof. BV Sreekantan
Sr Homi Bhabha Fellow
National Institute of Advanced Studies
Indian Institute of Science Campus
Bangalore – 560 012

Dr (Mrs) Wakako Hironaka
Member, House of Councillors
2-1-1, Nagata-cho, Chiyoda-ku
Tokyo 100
Japan

Dr (Mrs) Manju Sharma
Secretary
Department of Biotechnology
Ministry of Science and Technology
Block-2 (7th floor)
CGO Complex, Lodhi Road
New Delhi – 110 003

Mr Tejendra Khanna, IAS (Retd)
Chairman
Ranbaxy Laboratories Limited
(Former Lt Governor, Delhi)
19, Nehru Place
New Delhi – 110 019

Mr Deepak S Parekh
Chairman
Housing Development Finance Corporation Ltd
Ramon House, H T Parekh Marg
169 Backbay Reclamation, Churchgate
Mumbai – 400 020

Dr R K Pachauri
Director-General
TERI, Darbari Seth Block
Habitat Place, Lodhi Road
New Delhi – 110 003

TERI
Energy
Data
Directory &
Yearbook

2001/02

teri

© Tata Energy Research Institute 2002

ISBN 81-85419-94-9

All rights reserved. No part of this publication may be reproduced in any form or by any means without the prior permission of the Tata Energy Research Institute.

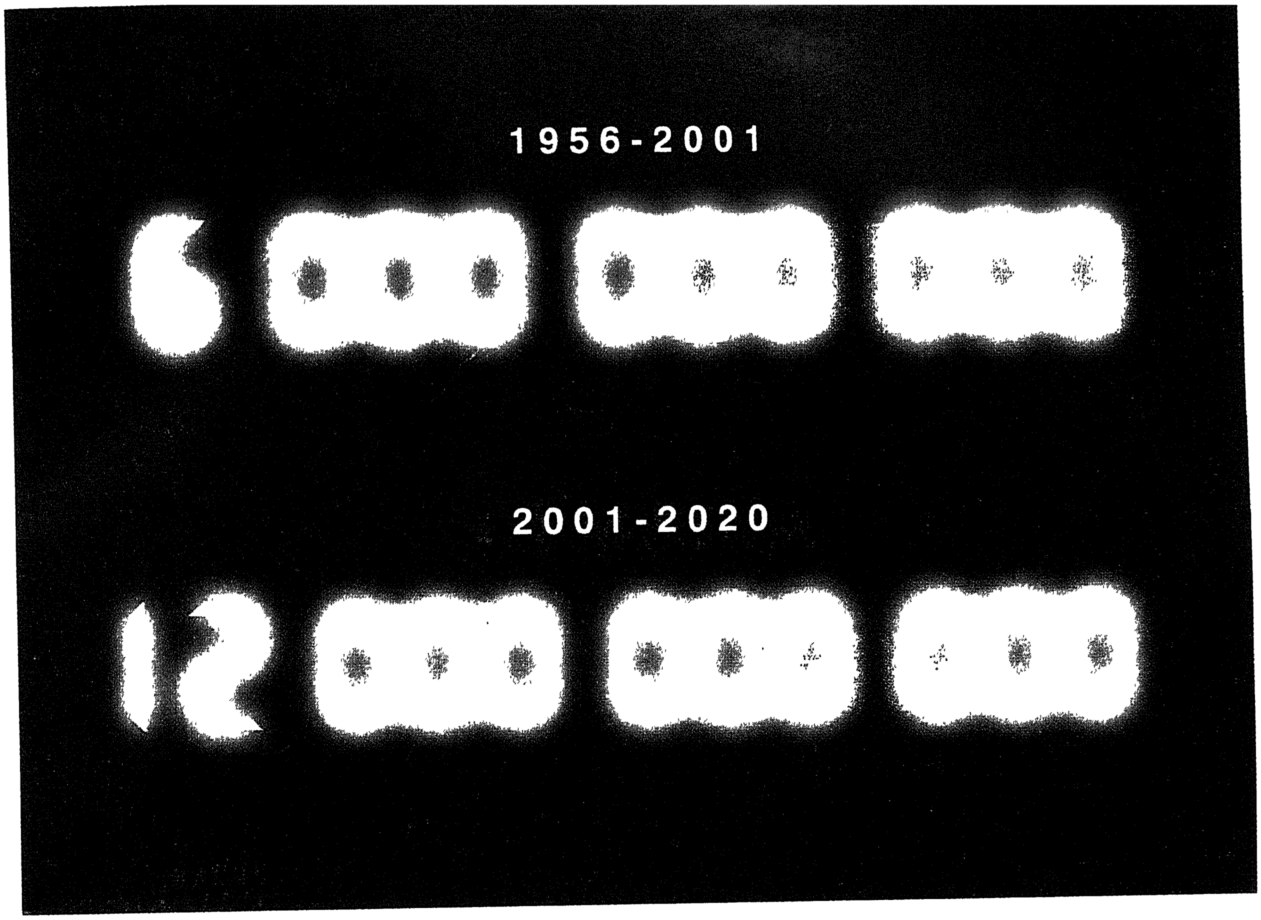
Published by
TERI
Darbari Seth Block
Habitat Place
Lodhi Road
New Delhi – 110 003
India

Telephone 468 2100 or 468 2111
E-mail mailbox@teri.res.in
Fax 468 2144 or 468 2145
Web site www.teriin.org
City code 11
Country code 91

TERI-NA
1600 Wilson Boulevard
Suite 710, Arlington
VA 22209, USA

Telephone +1 703 841 1136
E-mail teri@igc.org
Fax +1 703 243 1865
Web site www.teriin.org

Printed at Multiplexus (India), 94 B D Estate, Timarpur, Delhi – 110 054



The quest began on this day, in 1956

In 45 years, we have found 6 billion tonnes of oil & gas

(Initial In-place Oil & Oil Equivalent) in India.

In the next 20 years, we aim to find another 6 billion tonnes.

ONGCpeople Making dreams happen.

Sagar Samrat
India's first Offshore Rig 27 year of service
270 kms cumulative drilling
125 well completed Unmatched in the world

making tomorrow brighter

Oil and Natural Gas Corporation Ltd.

Jeevan Bharati Building, Tower II,
124, Indira Chowk, New Delhi-110001
Tel. EPABX · 3310156-58, 3310880
Fax . 011-3316413 Gram . COMONG
Visit us at : http://www.ongcindia.com

Efficiently lighting up the world

ASIAN E+

ENERGY EFFICIENT TUBELIGHT SYSTEM

With New Generation T-5 Lamp

UP TO 45% POWER SAVINGS

Energy efficient

- 45% or more power savings in lighting power bills.
- High power factor, more than 0.95.
- Higher light efficiency, upto 104 lumens / watt.

Latest Technology

- Operating range 130V to 300 V.
- Excellent lux maintenance during life span.
- Efficient Electronic Ballast (ECG) with Cut-off technology.
- High Colour Rendition Index (CRI) of 85.

QUALITY LIFE 4 POWER COSTS BILLS

4 TI LIFE

Unique Retrofit Concept

- Straight replacement in existing fitting.
- No change in wiring.

Aesthetic Appeal

- Light, Sleek & Compact.
- All plastic body.

Easy INSTALLATION fitting No change in wiring

Guarantee

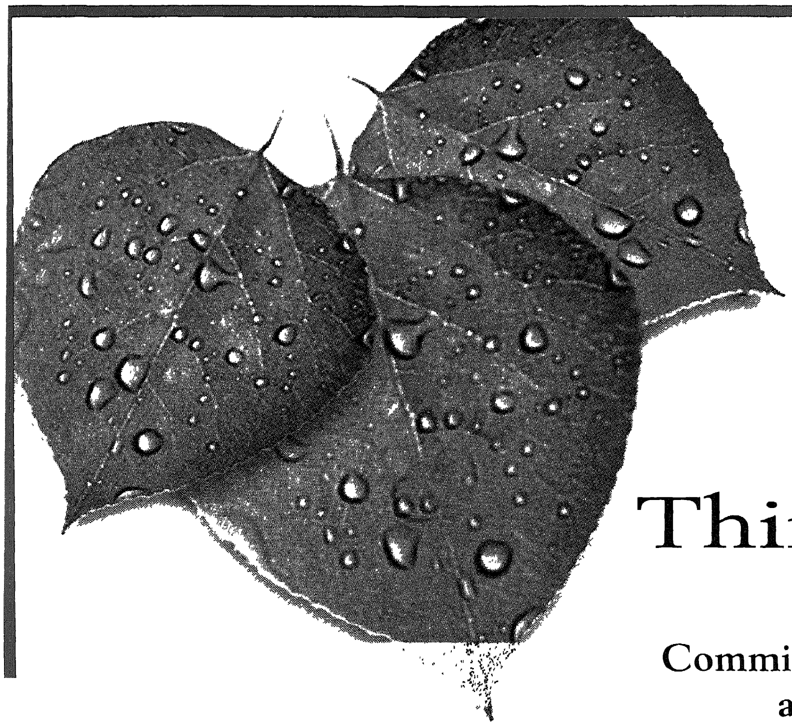
- Comprehensive - covers both ECG & Lamp.

STAND ALONE model also available for new installations.

ENERGY SAVING PRODUCTS AND SYSTEMS
ASIAN
ASIAN ELECTRONICS LTD.

NEW DELHI : Ph 91-11-6317232, 6929073, 6929075 Fax 91-11-6837406 E-mail. aeldel@vsnl com
CALCUTTA : Ph 91-33-4131825, 4839698 Fax 91-33-4130133 Email. aelcal@cal2 vsnl net in
MUMBAI : Ph.: 91-22-5835504-11, Fax 91-22-5827636 E-mail aeltha@vsnl.com
AHMEDABAD : Ph.: 91-79-6560691, Fax 91-79-6564673, E-mail aelahd@ad1 vsnl.net in
CHENNAI : Ph.: 91-44-4468003, Tele Fax 91-44-4460794, E-mail aelmds@vsnl com
SECUNDERABAD : PH 91-40-7841795, 7818050 Tele Fax. 91-40-7750495 E-mail aelhyd2@b2 net in

Generating Savings for Generations



Think Green.

HUDCO

Committed to a greener, safer and better India.

At HUDCO, green is more than just a colour. It is a commitment to greener, safer and sustainable human settlements. Encouraging cities to develop green lungs thus granting people the power of healthy living.

It is about promoting traditional, eco-friendly, energy efficient and sound building materials and technologies. Thus encouraging use of building materials based on agricultural and industrial wastes.

It is about creating ecologically appropriate infrastructure for integrated water management through aquifer recharging, rain-water harvesting and waste-water recycling.

And integrated waste management through composting, incinerators, autoclaves, hydroclaves and microwaves including energy generation through non-conventional and renewable sources.

At HUDCO, green is a philosophy - a concern for sustainable development - not just for today but for generations ahead.

HUDCO - a part of your life, in more ways than one

hudco

The foundation for a stronger India

Housing and Urban Development Corporation Limited

Hudco Bhavan, India Habitat Centre, Lodhi Road, New Delhi - 110 003. Tel: 4648193/94/95. Fax: 4625308.

E-mail: hudco@vsnl.com Or visit www.hudco.org

MAA Bozell-Hudco-47-01

*Pure*Energy
Gas Cogeneration Plants

Plug in

There's no secret behind the success of our Pure Energy plant Just hard work and a good deal of determination. Over the years we've learned what it takes to develop gas engine technology with outstanding performance. Consequently, we now have the most extensive range of gas engines. And this brings increased value to our customers.

Our Pure Energy plants let you locate energy sources exactly where they're needed. Which leads to higher efficiency, lower emissions, and improved overall economy.

Wartsila has extensive experience and full knowledge of the power plant and cogeneration business: engines, generating sets, project development, financing, operation & maintenance, and a global service network with a location close to you. In short, with our proven Pure Energy concept, we have what it takes to assure your peace of mind. All you have to do is plug it in.

WÄRTSILÄ

Power for a changing world www wartsila com

Wärtsilä India Ltd.
Mumbai Fax +91 22 757 5176 / 77 / 78, ***New Delhi*** Fax +91 11 625 1109 / 625 0914
Chennai Fax +91 44 230 1089

Contents

Preface *xi*
Acknowledgements *xiii*
Project team *xv*
List of tables *xvii*
Technology for a sustainable energy future ***1***
Organization of the energy sector ***7***
Indian energy sector: an overview ***13***

Energy supply

Coal and lignite ***25***
  Map 1 Coalfields and coal consuming industries (December 2001) *Facing page no. 26*
Oil and gas ***67***
  Map 1 Crude pipelines: existing, under construction, and proposed refineries (December 2001) *Facing page no. 72*
  Map 2 Product pipelines: existing, under construction, and proposed refineries (December 2001) *Facing page no. 73*
  Map 3 Prominent LNG (liquefied natural gas) terminals (December 2001) *Facing page no. 76*
  Map 4 HBJ (Hazira–Bijapur–Jagdishpur) transmission system *Facing page no. 77*
Power ***107***
  Map 1 Major power generating units of India (December 2001) *Facing page no. 110*
  Map 2 Grid map of India (2001) *Facing page no. 111*
Renewable energy sources and technologies ***159***
  Map 1 Wind resource in 10 states in India at 50 m above ground *Facing page no. 164*

Energy demand

Agriculture ***197***
Industry ***219***
Transport ***245***
Domestic sector ***287***
Forests ***321***
  Map 1 National vegetation map of India (2001) *Facing page no. 322*

Local and global environment

Environment ***339***
Global environment issues ***387***

Appendix ***441***

INDEX ***443***

Preface

Over the years, *TEDDY* (*TERI Energy Data Directory & Yearbook*) has consolidated its position among India's most comprehensive and reliable sources of information on energy and the environment.

Year on year, *TEDDY* strives to provide updates on various fronts of the Indian energy sector—demand, supply, environmental aspects, and policy initiatives. Its electronic counterpart, *TEDDY Online+* (Winweb version) also provides accurate and up-to-date time-series and cross-sectional data on energy demand, energy supply, environment, and the economy.

The theme chapter of *TEDDY 2001/02* focuses on the role of technology in sustainable patterns of energy development. As always, the subsequent chapters provide updates and insights on developments in the Indian energy sector and on local and global environmental concerns.

As readers and users of *TEDDY*, your comments and suggestions are welcome and valued greatly. *TEDDY* is ever evolving in an endeavour to meet your information needs.

R K Pachauri
Director-General, TERI

Order Form

Please send me the following:

TEDDY Online+ Winweb Version

- Stand-alone single user Rs 7500 (Indian) or US $750 (overseas)
- LAN single location unlimited user Rs 15 000 (Indian) or US $1500 (overseas)
- WAN multi location organizational network unlimited user Rs 30 000 (Indian) or US $3000 (overseas)

Media: CD ☐

Name ______________________________

Designation ______________________________

Organization ______________________________

Address ______________________________

Phone ____________ Fax ____________ e-mail ____________

A draft (No.____________ dated____________ for Rs__________)
favouring **Tata Energy Research Institute**, payable at New Delhi, is enclosed.

I/We would like to be charged on my/our Master/VISA/American Express/Diners.

Card No. ____________________ Expires on ______________

CVV NO. ________ (last 3 digits on the reverse of card)

Card holder's name ____________________ Date of birth__________

Date __________________ Signature ____________________

All orders and enquiries to

Information Dissemination Services
TERI
Darbari Seth Block
Habitat Place, Lodhi Road
New Delhi - 110 003, India

Fax +91 11 468 2144, 468 2145
E-mail outreach@teri.res.in
Telephone +91 11 468 2100, 468 2111
Web site http://www.teriin.org

Acknowledgements

TERI, New Delhi, acknowledges the officials of the following ministries/organizations of the Government of India for providing the latest published statistical documents for compiling this issue of TEDDY.

- Central Electricity Authority
- Central Pollution Control Board
- Central Statistical Organisation
- Ministry of Agriculture
- Ministry of Civil Aviation
- Ministry of Coal
- Ministry of Environment and Forests
- Ministry of Finance
- Ministry of Industry
- Ministry of Non-conventional Energy Sources
- Ministry of Petroleum and Natural Gas
- Ministry of Planning and Programme Implementation
- Ministry of Power
- Ministry of Railways
- Ministry of Steel
- Ministry of Surface Transport
- National Council of Applied Economic Research
- Office of the Registrar General and Census Commissioner
- Planning Commission
- Steel Authority of India Limited

List of Advertisers

Name of the advertisers	**Position**
Reliance Industries Limited	Back cover
GE Power Systems India Private Limited	Inside front cover
PSL Holdings Limited	Inside back cover
Asian Wind Turbines (Pvt.) Limited	End paper I
Enercon India Limited	End paper II
Suzlon Energy Limited	End paper III
Unocal	End paper IV
Wartsila India Limited	Facing the contents page
Oil and Natural Gas Corporation	v
Asian Electronics Limited	vi
Housing and Urban Development Corporation Limited	vii
Indian Oil Corporation Limited	p. 64
Gas Authority of India Limited	p. 65
Oil India Limited	p. 66
The Control Group	p. 105
Power Finance Corporation Limited	p. 106
National Thermal Power Corporation Limited	p. 158
Tata Iron and Steel Company Limited	p. 218
Petroleum Conservation Research Association	p. 243
Tata Engineering and Locomotive Company Limited	p. 244

Project team

Coordinators

Rekha Krishnan
Shilpi Banerjee

Core team for chapters

Technology for a sustainable energy future
R K Pachauri

Organization of the energy sector
Pooja Manchanda

The Indian energy sector: an overview
Shilpi Banerjee
Rekha Krishnan

Coal and lignite
S K Chand
Pooja Manchanda

Oil and gas
Rahul Deep Singh

Power
C Anjanappa
Pallavi Paul

Renewable energy sources and technologies
Amit Kumar

Agriculture
G K Girisha

Industry
Amit Kumar Tyagi
Pankaj Mohan

Transport
K S Nesamani

Domestic
I H Rehman
Preeti Malhotra
Dilip Singh

	Forests S P Banerjee
	Environment Shaleen Singhal Sumeet Saksena
	Global environment issues Pia Sethi Ulka Kelkar
	GIS maps Bhujanga Rao Akram Javed
Data compilation	D Ramela Shanthi
Advisors	S Sunder (Transport) R K Batra (Oil and gas) P V Sridharan (Coal and lignite) K Ramanathan (Power) Rakesh Kacker (Organization)
Reviewers	Somnath Bhattacharjee Preety Bhandari Leena Srivastava Vibha Dhawan
Documentation and indexing	P K Bhattacharya Subrato Deb N Deepa P K Jayanthan Debal C Kar
Editing, graphics, and production	Anshu Eashwar K P Eashwar R K Joshi Yateendra Joshi R Ajith Kumar T Radhakrishnan Vani J Shankar
Information dissemination	Jitendra Bakshi Beena Menon Sandeep Sood
Secretarial help	Kiran Shivpuri B Sudheer

List of tables

Overview

1 Commercial energy balance (million tonnes of oil equivalent): 1999/2000 19
2 Commercial energy balance (million tonnes of oil equivalent): 1998/99 20
3 Commercial energy balance (million tonnes of oil equivalent): 1997/98 21

Coal and lignite

1.01 Coal resources of states (million tonnes): 1 January 2001 34
1.02 Coal reserves by category (million tonnes): 1 January 2001 34
1.03 Lignite reserves of states and union territories (million tonnes): 1999/2000 35
1.04 All-India production of coal, lignite, and other derivatives (million tonnes): 1975/76 to 1999/2000 36
1.05 Coal production of various states (million tonnes): 1975/76 to 2000/2001 37
1.06 Coal despatches of various states (million tonnes): 1975/76 to 2000/2001 38
1.07 Coal pithead stock of various states (million tonnes): 1975/76 to 2000/01 39
1.08 Coal production of various companies (million tonnes): 1993/94 to 2000/01 40
1.09 Coal despatches of various companies (million tonnes): 1993/94 to 2000/01 40
1.10 Coal pithead stock of various companies (million tonnes): 1993/94 to 2000/01 41
1.11 Production (million tonnes) of coking coal and non-coking coal by companies and fields: 1994/95 to 1999/2000 42
1.12 Import of coking and non-coking coal (million tonnes): 1991/92 to 2000/01 44
1.13 Allotted captive mining blocks: March 1997 44
1.14 OMS (Output per man-shift) in opencast and underground mining (tonnes): 1975/76 to 2000/01 45
1.15 Categorization of coal and coke 46
1.16 Comparison of GCV (gross calorific value) and UHV (useful heat value) for non-coking coal (with six per cent moisture content) 47
1.17 Production from coal washeries (million tonnes): 1990/91 to 1999/2000 47
1.18 Raw coal feed (million tonnes) and clean coal production (million tonnes) of washeries: 1993/94 to 1999/2000 48
1.19 Inter-modal split of coal movement: 1977/78 to 2000/01 50
1.20 Capacity and traffic handled at major ports (million tonnes): 1999/2000 50
1.21 Average cost of production (rupees per tonne) of the CIL (Coal India Ltd) and the SCCL (Singareni Collieries Company Ltd) coal: 1993/94 to 1998/99 51
1.22 Average pithead unit value (rupees per tonne) of coal: 1974/75 to 1997/98 51
1.23 Average pithead prices (rupees per tonne) of the CIL (Coal India Ltd) and the SCCL (Singareni Collieries Company Ltd) coal: 1991 to 1999 52
1.24 Annual average import price of coal (dollars per tonne): 1994 to 1997 52
1.25 Customs duty structure on imported coal: 2000/01 53
1.26 Royalty (million rupees) paid on coal by states: 1991/92 to 1998/99 53
1.27 Revised rates of royalty (rupees per tonne) 53
1.28 Selling price of coal in respect of the CIL (Coal India Ltd) and subsidiaries (rupees per tonne): 31 January 2001 54
1.29 Plan expenditure and the share of coal and total energy (million rupees) 58
1.30 Annual Plan expenditure during the Eighth Five-Year Plan and actual expenditure (million rupees) 59
1.31 Net budgetary support as percentage of actual plan expenditure in coal: 1992/93 to 1996/97 60
1.32 Availability and estimated sectorwise consumption of raw coal (million tonnes): 1990/91 to 1997/98 60
1.33A Supply (thousand tonnes) of coal to steel plants: 1996/97 to 1997/98 61
1.33B Supply (thousand tonnes) of coal to steel plants: 1998/99 to 1999/2000 62
1.34 Sectoral offtake from the CIL (Coal India Ltd) and the SCCL (Singareni Collieries Company Ltd) (million tonnes): April–December 1999/2000 63

Oil and gas

1.35 Proven and balance recoverable reserves of crude oil (million tonnes) and natural gas (billion cubic metres) by state: 1990 to 2000 79
1.36 Exploratory and developmental drilling by the Oil and Natural Gas Corporation Ltd and the Oil India Ltd: 1990/91 to 1999/2000 80
1.37 Production (thousand tonnes) of crude oil: 1985/86 to April–December 2000 81
1.38 Production (million cubic metres) of natural gas: 1990/91 to 2000 82
1.39 Reserve replacement ratio and life of reserves for crude oil (million tonnes) and natural gas (billion cubic metres): 1990 to 1999/2000 83
1.40 Installed capacity (thousand tonnes) and refinery crude throughput: 1990/91 to 1999/2000 84
1.41 Refinery crude throughput and production (thousand tonnes) of petroleum products: 1990/91 to 1999/2000 84
1.42 Production (thousand tonnes) of petroleum products: 1990/91 to 2000 85
1.43 Crude oil and petroleum products trade (quantity and value): 1990/91 to 1999/2000 86
1.44A Imports (thousand tonnes) of crude oil and petroleum products: 1990/91 to 2000 87
1.44B Exports (thousand tonnes) of crude oil and petroleum products: 1990/91 to April–December 2000 88
1.45 Movement of petroleum products by railways: 1990/91 to 1999/2000 89
1.46 Petroleum products handled at major ports (million tonnes) 89
1.47 Product storage and movement: 1993/94 to 1999/2000 89
1.48 Sales/consumption of petroleum products (thousand tonnes): 1990/91 to 2000 90
1.49 Average annual compound growth rates of consumption of petroleum products (%) 91
1.50 Consumption (thousand tonnes) of major petroleum products: 1999/2000 (PSU sales only) 92
1.51 Offtake (million cubic metres) of natural gas by industry: 1990/91 to 1999/2000 94
1.52 Subsidies on major petroleum products and subsidies by the central government (million rupees): 1991/92 to 1999/2000 94
1.53 Development of spot prices of key Organization of the Petroleum Exporting Countries crudes (dollars per barrel): 1998 to 2000 95
1.54 Realization of excise and customs duties from crude oil and petroleum products (million rupees): 1990/91 to 1999/2000 96
1.55 Development of (ex-storage point) basic ceiling selling prices (rupees per selling unit) of petroleum products: 1990 to 1999 97
1.56 Retail selling price of selected petroleum products in metropolitan cities and towns: 1996 to 2000 98
1.57 Consumer prices of natural gas (rupees) (excluding royalty, taxes and all statutory levies) 100
1.58 Eighth Plan outlay and actual expenditure of petroleum and natural gas (million rupees) 101
1.59A International petroleum statistics: 1990 to 1999 102
1.59B International petroleum statistics: 1990 to 1999 103
1.60 CNG (compressed natural gas) activities in India as on 1 April 2000 104

Power

1.61 Power scenario in India 117
1.62 Per capita consumption of electricity: 1986/87 to 1998/99 118
1.63 Distribution of power sector outlay for 1999/2000 and total outlay: 1999/2000 to 2000/01 119
1.64 Installed capacity (MW): 31 March 2001 120
1.65 Installed capacity of utilities by region and state (MW): 31 March 2001 122
1.66 Annual plant load factor (%) of thermal stations: 1991/92 to 2000/01 123
1.67 Annual gross generation in utilities (GWh): 1975/76 to 2000/01 124
1.68 Captive capacity (MW) and generation (GWh): 1990/91 to 1997/98 (in respect of installed capacity of 1 MW and above) 125
1.69 Purchase of power by major sources (million kWh): 1997/98 to 2000/01 126
1.70 Installed capacity in selected industries: 1997/98 127
1.71 Electricity production and consumption (GWh) in selected industries: 1997/98 128
1.72 Details of nuclear power projects: 31 March 2001 129
1.73 Potential and development of hydro-electric power projects (MW) in different regions: 31 March 1996 . 130
1.74 Potential hydroelectric power projects (MW) of different basins 130
1.75 Transmission and distribution losses as a percentage of availability in state electricity departments: 1991/92 to 2000/2001 131
1.76 Length of transmission and distribution lines (circuit km) by region and state: 31 March 1998 132

1.77 Villages electrified and rural population benefitted by electricity in different regions and states: 1997 to 2000 134
1.78 Energization of pump-sets: March 1995 to March 2000 135
1.79 Progress in rural electrification: 1970/71 to 1999/2000 136
1.80 Number of towns electrified for various population groups: 1970/71 to 1995/96 136
1.81 Cost structure (paise/kWh of sale) of state electricity boards: 2000/01 137
1.82 Unit cost of power supply (paise/kWh): 1991/92 to 2000/01 138
1.83 Consumer categorywise average tariff of electricity (paise/kWh): 2000/01 139
1.84 Average tariff for sale of electricity (paise/kWh): 1991/92 to 2000/01 140
1.85 Revenue arrears receivable by state electricity boards (million rupees): 1994/95 to 1997/98 141
1.86 Effective subsidy for agricultural consumers (million rupees): 1992/93 to 2000/01 142
1.87 Subsidy for domestic consumers (million rupees): 1992/93 to 2000/01 143
1.88 Cross-subsidy from other users (million rupees): 1992/93 to 1999/2000 144
1.89 Subsidy to sales revenue ratio (with cross-subsidization) (%): 1992/93 to 2000/01 145
1.90 Sales revenue as a ratio of cost (%): 1992/93 to 2000/01 146
1.91 Percentage of unit cost of supply recovered from the consumer tariff by category: 1999/2000 147
1.92 Number of consumers (thousands) and connected load (MW): 1990/91 to 1997/98 148
1.93 Commercial profit/loss (Rs crore) for state electricity boards (with subsidy): 1992/93 to 2000/01 149
1.94 Commercial profit/loss (Rs crore) for state electricity boards (without subsidy): 1992/93 to 2000/01 150
1.95 State electricity boards' rate of return on capital (%) (with subsidy): 1992/93 to 2000/01 151
1.96 State electricity boards' rate of return on capital (%) (without subsidy): 1992/93 to 2000/01 152
1.97 State electricity boards' rate of return on capital (%) (with 50 paise/kWh for agriculture): 1992/93 to 2000/01 153
1.98 Sale of power to consumer by category (MWh): 2000/01 154
1.99 Plan outlay and expenditure (million rupees) for power sector 155
1.100 List of private sector projects commissioned (project-wise since 1991) as on 31 January 2001 156
1.101 Private power projects identified for implementation during Ninth Plan 157

Renewable energy sources and technologies

1.102 Renewable energy potential and achievements in India 176
1.103 Capacity addition of various sources of non-conventional energy during 2000 176
1.104 Global position (MW) of Indian renewable energy programmes 176
1.105 Progress in programmes during the Ninth Plan 177
1.106 Potential for bagasse-based cogeneration in major sugar-producing states in India (MW) 177
1.107 Biomass power and cogeneration status as on 31 December 2001 177
1.108 Statewise and yearwise composition of commissioned biomass power cogeneration projects (MW): 1992/93 to 2000/01 178
1.109 Statewise number and capacity of biomass gasifiers installed up to 31 December 2000 178
1.110 Completed grid-interactive solar power projects 179
1.111 Grid-interactive solar PV power projects under installation 179
1.112 Wind power installed capacity (MW): 2000 and 2001 180
1.113 Wind power installed capacity (MW): 1991/92 to 2000/01 180
1.114 Total generation from wind power projects (kWh): 31 December 2000 180
1.115 Statewise cumulative generation from wind power projects in India (kWh): 1991/92 to 2000/01 181
1.116 Statewise wind monitoring stations in India: March 2001 182
1.117 Wind monitoring stations with annual mean wind power density greater than 150W/m²: November 2000 183
1.118 Extractable wind energy potential and possible installed capacities at 30-m height in 10 states 188
1.119 Extractable wind energy potential and possible installed capacities at 50-m height in 10 states 189
1.120 Small hydro potential sites (up to 25 MW) capacity identified in India 190
1.121 Different categories of urban municipal and industrial wastes and their estimated quantity 190
1.122 Urban and industrial waste projects completed, under execution, and under development 191
1.123 Urban and industrial waste projects (MW) 191
1.124 National project on biogas development statewise coverage up to 1999/2000 and achievements and targets: 2000/01 (no. of plants) 192
1.125 Statewise and agencywise achievements as against targets for 2000/01 under the National Programme on Improved Chulhas 193

Agriculture

2.01 Contribution (million rupees) of agricultural sector to GDP (gross domestic product) and NDP (net domestic product) at current and constant prices: 1990/91 to 1998/99 202
2.02 Land-use classification (million hectares): 1990/91 to 1996/97 202
2.03 Area (million hectares) under principal crops: 1990/91 to 1999/2000 203
2.04 Production (million tonnes) and yield (kg/ha) of principal crops: 1990/91 to 1999/2000 204
2.05 Area (million hectares) under high-yielding varieties: 1970/71 to 1997/98 205
2.06 Progress of India's selected agricultural development programmes (million hectares): 1990/91 to 1997/98 206
2.07 Performance of total rainfall in a year 206
2.08 Development of irrigation potential (million hectares) during Plan periods 207
2.09 Irrigated area (million hectares) under selected crops: 1990/91 to 1996/97 208
2.10 Irrigated area (million hectares) by various sources: 1990/91 to 1995/96 209
2.11 Consumption (million tonnes) of nitrogenous, phosphatic, and potassic fertilizers: 1991/92 to 2000/01 209
2.12 Production and consumption (tonnes) of technical-grade pesticides: 1989/90 to 1995/96 209
2.13 Consumption of pesticides (tonnes): 1985/86 to 1994/95 210
2.14 Progress of farm mechanization: 1970 to 1993 211
2.15 Contribution of various energy sources to farm power: 1991/92 211
2.16 Changes in various energy sources (number): 1971/72 to 1991/92 212
2.17 Number of pump sets energized: March 1995 to March 1999 213
2.18 Procurement/support prices (rupees per tonne) of foodgrains / commercial crops: 1990/91 to 2000/01 214
2.19 Public sector plan outlays (million rupees) on the agriculture sector during different five-year plans and annual plans 215
2.20 Agricultural perspective: 1984/85 to 2006/07 216
2.21 India's livestock population: 1977 to 1992 216
2.22 All-India pattern of outlay expenditure (million rupees) in public sector by plan 217

Industry

2.23 Energy consumption in industry: 1993/94 to 1998/99 227
2.24 Installed capacity (thousand tonnes), production (thousand tonnes), and capacity utilization (%) in the fertilizer industry: 1994/95 to 1999/2000 227
2.25 Imports (thousand tonnes) of fertilizers: 1994/95 to 1999/2000 228
2.26 Energy consumption in the fertilizer industry: 1993/94 to 1998/99 228
2.27 Specific energy consumption (Gcal/tonne) of ammonia: 1988/89 to 1997/98 228
2.28 Specific energy consumption (Gcal/tonne) of phosphatic fertilizer plants: 1991/92 to 1993/94 229
2.29 Capacity (thousand tonnes), production (thousand tonnes), and capacity utilization (%) of aluminium companies: 1999/2000 229
2.30 Installed capacity (thousand tonnes), production (thousand tonnes) and capacity utilization (%) of the aluminium industry: 1993/94 to 1999/2000 229
2.31 Specific energy consumption per tonne of aluminium: 1992/93 to 1999/2000 230
2.32 Performance parameters (per tonne of calcined alumina) of Indian aluminium plants: 1994/95 230
2.33 Production by the textile industry: 1994/95 to 1999/2000 231
2.34 Energy consumption in the textile industry: 1993/94 to 1997/98 232
2.35 Energy intensity of the textile industry 232
2.36 Power consumption (% of total) in different types of mills by section 232
2.37 Specific electricity consumption in textile mills 233
2.38 Growth of cement industry (million tonnes): 1990 to 2000 233
2.39 Fuel consumption in the cement industry: 1993/94 to 1998/99 234
2.40 Trends in variety of cement production (million tonnes): 1995 to 2000 234
2.41 Specific energy consumption in the cement industry 235
2.42 Finished steel production by producer (million tonnes): 1994/95 to 1999/2000 236
2.43 Production (million tonnes) of ingot steel: 1994/95 to 1999/2000 236
2.44 Crude steel production (million tonnes) by process: 1999 236
2.45 Sponge iron production (thousand tonnes) by producer: 1990/91 to 1996/97 237
2.46 Electricity generated, purchased, and consumed (GWh) in main steel plants: 1994/95 to 1999/2000 238
2.47 Energy consumption per tonne in sponge iron plants 238
2.48 Specific energy consumption (Gcal/tonne) in crude steel production: 1994/95 to 1999/2000 239

2.49 Installed capacity (million tonnes), production (million tonnes), and capacity utilization (%) in the paper industry: 1990/91 to 1998/99 239
2.50 Specific energy consumption in different process centres (mills) in the paper industry 240
2.51 Specific energy consumption norms for the pulp and paper industry 240
2.52 Installed capacity, production, and capacity utilization in chlor-alkali industry: 1995/96 to 1999/2000 241
2.53 Processwise production (thousand tonnes) of caustic soda: 1998/99 to 1999/2000 241
2.54 Specific energy consumption in different manufacturing sections in soda ash industry 242
2.55 Total energy consumption (kWh/tonne) for manufacturing caustic soda lye (48.5%) 242

Transport

✓2.56 GDP (Gross domestic product) in the transport sector (million rupees): 1980/81 to 1997/98 258
2.57 Petroleum oil, and lubricants consumption (thousand tonnes) in transport: 1990/91 to 1999/2000 259
2.58 Key data on transport: 1970/71 to 1999/2000 260
✓2.59 Registered motor vehicles (thousands): 1975 to 1998 262
✓2.60 Registered taxed and tax-exempted motor vehicles (numbers) in metropolitan cities: 1997/98 263
2.61 Buses owned (thousands) by public and private sectors: 1975 to 1998 264
2.62 Road length (km) by category: 1991 to 1997 264
2.63 Total and surfaced length (km) of national highways (as on 31 March): 1991 to 1997 265
2.64 Road length in relation to area and population in states and union territories: 31 March 1997 266
2.65 Status of BOT (build-operate-transfer) projects awarded as on 25 November 1998 267
2.66 Utilization of fleet (for reporting state road transport undertakings): 1998/99 268
2.67 Road accidents (thousands): 1991 to 1998 268
2.68 Motor vehicle accidents (numbers) in metropolitan cities: 1996 to 1998 269
2.69 Railway traffic: 1970/71 to 1999/2000 270
2.70 Electrification of railway routes and tracks (km): 1970/71 to 1999/2000 270
2.71 Energy intensity in railways (consumption per thousand gross tonne-km): 1996/97 to 1999/2000 271
2.72 Trends in relative rail and road traffic: 1970/71 to 1996/97 272
2.73 Indian shipping gross registered tonnage (million): 1971 to 1999 272
2.74 Cargo carried and freight earned by the Central Inland Water Transport Corporation by commodity: 1996/97 to 1999/2000 273
2.75 Capacity available at major ports (million tonnes): 1992 to 2000 274
2.76A Cargo traffic handled (million tonnes) (commoditywise) at major ports: 1970/71 to 1998/99 275
2.76B Cargo traffic handled (million tonnes) (commoditywise) at minor ports: 1990/91 to 1998/99 276
2.77 Commodity traffic at various ports (million tonnes): 1996/97 and 1997/98 277
2.78 Private sector/captive port projects approved: as on 31 December 1999 278
2.79 Growth of civil aviation: 1970/71 to 1999/2000 279
2.80 Annual comparative statement of scheduled services of national carriers 280
2.81 Physical performance of the Indian Airlines: 1993/94 to 1999/2000 281
2.82 Total domestic passenger traffic (million) carried by the Indian Airlines, the Air India, and the Vayudoot: 1985/86 to 1994/95 281
2.83 Total domestic and operating statistics of the Indian Airlines, the Air India, and the Vayudoot 282
2.84 Total traffic and operating statistics of all scheduled services of the Indian Airlines: 1985 to 1997/98 283
2.85 Total traffic and operating statistics of all scheduled services of the Air India: 1985 to 1997/98 284
2.86 Aviation Turbine Fuel offtake (thousand tonnes): 1970/71 to 1999/2000 285

Domestic sector

2.87 Urban population and settlements in India: 1901 to 1991 (census years) 297
2.88 Consumer's monthly per capita expenditure (%) on fuel and light 298
2.89 Households having electricity connection (%): 1981 and 1991 299
2.90 All-India purchases of durable products (million) (rural and urban): 1985/86 to 1995/96 300
2.91 Purchases of durable products (rural share) (%): 1985/86 to 1995/96 301
2.92 Distribution of households (rural and urban) by fuel used (%): 1974 to 1991 301
2.93 Rural households by primary source of energy for cooking for each MPCE (monthly per capita expenditure) class (%) 302
2.94 Urban households by primary source of energy for cooking for each MPCE (monthly per capita expenditure) class (%) 303
2.95 Consumption of fuel in rural areas (states) (rupees): 1983/84 and 1993/94 304

2.96 Consumption of fuel in urban areas (states) (rupees): 1983/84 and 1993/94 305
2.97 Conversion efficiency of fuels used for cooking (%) 306
2.98 All-India estimates of commercial energy consumption in the domestic sector: 1980/81 to March 1997 306
2.99 Annual per capita energy consumption in rural and urban areas: 1973/74 and 1978/79 307
2.100 Change in energy consumption in the household sector: 1970/71 and 1982/83 307
2.101 National aggregates of biofuel use in the rural domestic sector (million tonnes per year) 308
2.102 Daily per capita consumption of biofuels in rural households in different agroclimatic zones (kg): 1992 309
2.103 Energy consumption in rural households: 1978/79 and 1992/93 309
2.104 Monthly per capita fuel consumption in rural areas (states): 1993/94 310
2.105 Monthly per capita fuel consumption in urban areas (states): 1993/94 310
2.106 Assumptions for projecting energy demand for cooking 311
2.107 Projections for energy demand for cooking and lighting 311
2.108 Projected annual consumption of different fuels by urban households of different income groups (per capita) 312
2.109 Annual demand for different fuels: 1989/90 to 2004/05 312
2.110 Demand for heating energy and likely pattern of fuel use in rural households: 2001/02 and 2006/07 313
2.111 Primary source of energy for lighting in rural and urban households (%): 1988/89 and 1993/94 313
2.112 Households (all-India) using different fuels for cooking (%): 1991 314
2.113 Distribution of rural households by primary source of energy (traditional) for cooking (states) (%): 1989/90 to 1993/94 315
2.114 Distribution of rural households by primary source of energy (commercial) for cooking (states) (%): 1989/90 to 1993/94 316
2.115 Distribution of urban household by primary source of energy (traditional) for cooking (states) (%): 1989/90 to 1993/94 317
2.116 Distribution of urban household by primary source of energy (commercial) for cooking (states) (%): 1989/90 to 1993/94 318

Forests

3.01 Contribution (million rupees) of forestry and logging to the GDP (gross domestic product) and its share (%): 1980/81 to 1998/99 327
3.02 Extent of dense forest, open forest, and mangroves (km^2): 1999 assessment 328
3.03 Productivity of forests (m^3/ha) 329
3.04 Statewise annual fuelwood availability and biofuel consumption (air dry million tonnes) 330
3.05 Fuelwood demand (million tonnes/year) and total availability of land (million hectares) 331
3.06 Sources of supply of woodfuels in India 332
3.07 Demand–supply situation of industrial wood in round-wood equivalent (million cubic metres) 332
3.08 Demand and availability of wood/timber from all sources under accelerated management option (million cubic metres) 333
3.09 The extent (%) of regeneration in forests in selected states and union territories: 1987 and 1995 334
3.10 Intensity and extent of grazing in forests: 1991 to 1993 335
3.11 Wood consumption (million cubic metres): 1987 to 2010 335
3.12 Scenario of industrial wood (million cubic metres): 1947 and 1997 336
3.13 Changes in area under forests (million hectares): 1987 to 1999 336
3.14 Future scenario: 1997 and 2019 336

Environment

4.01 Environmental legislation, acts, rules, notifications, and amendments 353
4.02 List of projects that require environmental clearance 354
4.03 NAAQS (National ambient air quality standards) for India 355
4.04 World Health Organization guideline values (µg/m^3) for the classical air pollutants 356
4.05 Noise standards 356
4.06 Criteria for classification of inland surface water 357
4.07 Maximum permissible limits (mg/litre) for industrial effluent discharges 358
4.08 Effluent standards for integrated iron and steel plants 359
4.09 Effluent standards for Al (aluminium) industry 359
4.10 Effluent standards for sugar industry 360

4.11 Effluent standards for large pulp and paper industries ... 360
4.12 Effluent standards (mg/litre, except for pH) for oil refinery industry ... 360
4.13 Effluent standards (mg/litre, except for pH) for petrochemical (basic and intermediates) industry ... 361
4.14 Effluent standards for thermal power plants ... 362
4.15 Maximum permissible limits (mg/m^3) for emissions of particulate matter from thermal power stations ... 362
4.16 Guidelines for minimum stack heights ... 363
4.17 Indian emission standards and proposed World Bank emission guidelines for thermal power plants ... 364
4.18 Maximum permissible limits (mg/m^3) for emissions from integrated iron and steel plants ... 365
4.19 Maximum permissible limits (mg/m^3) for emissions of particulate matter from cement plants ... 365
4.20 Maximum permissible limits (mg/m^3) for emissions from fertilizer plants ... 366
4.21 Maximum permissible limits (kg per tonne of feed) for emissions of sulphur dioxide from oil refineries ... 366
4.22 Maximum permissible limits (mg/m^3) for emissions of particulate matter from calcium carbide plants ... 366
4.23 Maximum permissible limits for emissions from copper, lead, and zinc smelting units ... 367
4.24 Maximum permissible limits (mg/m^3) for emissions of particulates from carbon black industry ... 367
4.25 Maximum permissible limits (mg/m^3) for emissions of particulate matter from aluminium industry ... 367
4.26 Emission factors (g/km) for different vehicles ... 368
4.27 Emission limits (%) for petrol-driven vehicles (idling condition) ... 368
4.28 Emission limits for diesel vehicles ... 368
4.29 Mass emission standards (g/km) for petrol-driven vehicles ... 369
4.30 Mass emission standards (g/kWh) for diesel-driven vehicles ... 370
4.31 Categories of biomedical waste ... 371
4.32 Ambient air quality levels in highly polluted cities (μg/m^3): 1998 ... 372
4.33 Average noise levels (dB[A]) in various metropolitan cities ... 374
4.34 Pollution control status of 17 categories of industries (no. of units): 31 December 2000 ... 374
4.35 Summary status of pollution contract in 17 categories of industries in states and union territories (no. of units): 31 December 2000 ... 375
4.36 List of polluted river stretches in India ... 376
4.37 GPIs (Grossly polluting industries) discharging into water course in states and union territories ... 377
4.38 Potable water quality standards as recommended by the WHO (mg/litre) ... 378
4.39 Municipal solid waste generation (kg per capita per day) in cities ... 379
4.40A Characteristics of municipal solid waste (%) on weight basis: 1971 to 1973 ... 380
4.40B Characteristics of municipal solid waste (%) on weight basis: 1995 ... 381
4.41 Status of municipal solid waste treatment and disposal in metro cities ... 382
4.42 Status of municipal solid waste management in selected metro cities ... 382
4.43 Status of hazardous waste generation in India ... 383
4.44 Mining waste (coal overburden removal) in the mechanized opencast mines (million cubic metres) in the Coal India Ltd: 1975/76 to 1992/93 ... 383
4.45 All-India distribution of deaths due to 10 selected diseases ... 384
4.46 Emission factors (g/kg) from cooking stoves for various fuel–stove combinations ... 384
4.47 Concentration of pollutants as a result of burning biofuels ... 385

Global environment issues

4.48 Status category summary by major taxonomic group (animals) ... 412
4.49 Status category summary by major taxonomic group (plants) ... 413
4.50 Countries ranked according to percentage of their territory with unusually high required migration rates (≥ 1000 m/year) ... 414
4.51 Biodiversity hotspots ... 415
4.52 The eight 'hottest' biodiversity hotspots in terms of five factors ... 416
4.53 Comparative statement of recorded number of plant species in India and the world ... 416
4.54 Comparative statement of recorded number of animal species in India and the world ... 417
4.55 Endemic species of plants ... 417
4.56 Endemic species of animals ... 417
4.57 Wild relatives of some crops and medicinal plants ... 418
4.58 Threatened species of India ... 418
4.59 Threatened plants of India by status category ... 418
4.60 Threatened animals of India by status category ... 419

.61 Biosphere reserves of India 419
.62 India's World Heritage sites 419
.63 Total existing and proposed protected areas (national parks and sanctuaries) in India by biogeographic zone 420
.64 Name of the Project Tiger reserves in tiger range states with year of creation and area 421
.65 Atmospheric concentrations of greenhouse and ozone-depleting gases: 1965 to 1996 422
.66 Timetable of reductions from baseline levels 423
.67 Estimated production of ozone depleting substances (tonnes) for India: 1996 to 2010 424
.68 Global average temperature and atmospheric concentrations of carbon dioxide: 1950 to 1998 425
.69 GHGs (greenhouse gases) and their main characteristics 426
.70 SRES (Special report on emission scenarios) projections of anthropogenic emissions for 2100 426
.71 Quantitative 2 × carbon dioxide damages in different world regions (2.5 °C warming) 427
.72 Aggregate monetary damage for 2 × carbon dioxide (annual damages) 427
.73 Effect of 1-m sea-level rise on coastal area and population 428
.74 Impact of 1-m sea-level rise on coastal districts (billion 1990 rupees) (4.5% rate of growth, 5% discount rate) 428
4.75 Global carbon dioxide emission estimates (million tonnes of carbon): 1970 to 1991 429
4.76 Carbon dioxide emission estimates (million tonnes of carbon) for India: 1970 to 1991 429
4.77 Greenhouse gas emissions from developed countries: 1990 to 1998 430
4.78 Average annual budget of carbon dioxide perturbations: 1980 to 1989 432
4.79 Estimated sources and sinks of methane (Tg per year): 1980 to 1990 432
4.80 India's national greenhouse gases inventory for 1990 (Gg) 433
4.81 CO_2-fuel combustion emissions, 1997, largest emitters: Annex I and non-Annex I Parties (million tonnes of CO_2) 434
4.82 CO_2-fuel combustion emissions, 1997, (per capita emissions) largest emitters: Annex I and non-Annex I Parties (tonnes of CO_2 per capita) 435
4.83 Share in 1990 Annex I CO_2 emissions and emissions reductions below 1990 levels (%) proposed in the Kyoto Protocol 436
4.84 Cost of various CO_2 mitigation options for India 437
4.85 GEF (Global Environment Facility) projects in India 438
4.86 Pilot-phase activities of projects implemented jointly and endorsed by the Government of India 439

Symbols used

The tables in the directory include some symbols which are explained below.

— or [?] = Not available
.. = Nil, or too small to be shown

Technology for a sustainable energy future

One major component of energy decisions as well as consumption and production trends relates to the status of technology in the various elements of the energy chain. Typically, the various energy flows in an economic system follow the broad pattern shown in Figure 1.

It would be seen from Figure 1 that production, transformation, and transmission of energy, as well as consumption efficiencies are determined by the state of technology defining these transactions. Hence, irrespective of the quantum of energy flowing through various stages of the energy cycle, technology is an important driver of efficiencies, costs and prices, as well as the pattern of production and consumption of energy in an economic system. Since technological change related to energy activities throughout the world has progressed at a dramatic pace, any future plans for the energy sector and its role in an economic system must take into account a technology vision related to energy production, conversion, and use. If we start at the consumption end of the cycle, we have to understand that the demand for energy is basically a derived demand, which depends on the following variables:

- prices and costs facing producers and consumers;
- technology and related variables defining the efficiency of production and use; and
- incomes of consumers, producers, and other actors in the sytem.

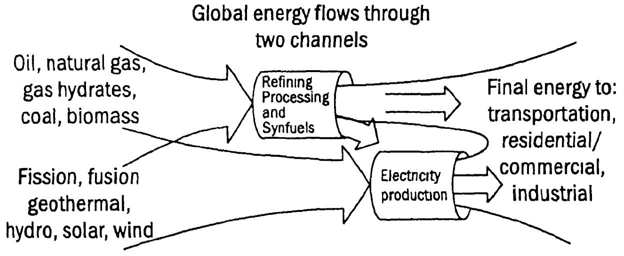

Global energy flows through two channels
Oil, natural gas, gas hydrates, coal, biomass
Fission, fusion geothermal, hydro, solar, wind
Refining Processing and Synfuels
Electricity production
Final energy to: transportation, residential/ commercial, industrial

Figure 1 Primary commercial energy flows through two channels to meet an ever-increasing array of end-use demands
Source Battelle Memorial Institute (undated)

The extent and nature of the demand for energy is a function of various energy services required in different sectors of the economy, such as lighting for household purposes or process heating in specific industry groups or energy for irrigation pumping in agriculture. Technology in each of these end uses is determined by prices and scarcity of energy employed for providing a particular energy service in keeping with the examples mentioned above. The structure of any set of activities for production of goods and services is defined by a relationship called the production function in which the major sets of inputs or factors of production that are used include

- K which represents capital,
- L stands for labour,
- E stands for energy, and
- M which represents raw material.

The manner in which these inputs are combined and useful outputs produced is essentially what in economic terms is known as technology. A labour-intensive technology would be one where a small amount of capital and large quantities of labour would provide one unit of useful output. On the other hand, a totally automated facility would employ very small quantities of labour and a large amount of capital to produce an identical level of useful output. In most production functions, energy and capital have a complementary relationship. In other words, a large quantity of capital is also generally accompanied by a large consumption of energy. Hence, technology can be defined by the proportion of inputs used for production of a certain level of goods and services. Technology is also sensitive to relative prices and costs of various inputs. Hence, if energy prices are to increase, the result would be the development of energy-efficient systems of production that minimize the use and, therefore, the expenditure on energy.

Energy prices in a relatively free market system would be an important determinant of the technology of production itself. However, energy prices in the market, both in a command-and-control as well as in a totally free market system, may not reflect the true costs of energy, because components such as environmental impacts and energy security considerations may not be included in prices of energy. These are externalities that government fiats as well as free markets may miss completely. Another aspect of technology and its impacts on the availability of energy relates to the vast opportunities that, for instance, decentralized and distributed energy systems can provide to large populations who currently may not have access to grid-based or centralized supply of energy. Innovation and new methods of producing and using energy can provide substantial welfare benefits. These are difficult to quantify, making energy pricing a complex subject. An example that could be quoted is the discovery of the filament lamp by Thomas Edison, which has provided inestimable economic welfare for the human race. Similarly, the possibility of refrigerating and transporting vaccines has major welfare benefits by making these available in areas that otherwise may not have access to basic medical facilities and medical services.

For a country like India, it is particularly necessary to develop an energy technology vision on the basis of which technology development and dissemination can be managed and promoted to provide economic benefits to society to the maximum possible extent. Most other nations have carried out comprehensive exercises to assess future technologies and likely choices that could be created. From the point of view of energy security, expanded access, environmental benefits, and dispersed employment generation, an energy mix and a set of technologies defining the production and consumption related to such a mix would be an important element of development policy and strategy. It is not necessary for an economic system to be rigidly planned through a set of centralized resource allocation decisions and command-and-control methods, but a vision of technology in the future can be realized and achieved through the use of proper fiscal instruments and necessary government support for R&D programmes or other forms of technology development activities. In the case of India, in particular, on all fronts including energy security considerations and the need for expanded access to clean forms of energy for a large chunk of our population, the subject of energy technology choices has to be elevated to a much higher level in national strategy formulation and development policies. The Global Energy Technology Strategy project implemented by the Battelle Memorial Institute with sponsorship from a number of other organizations has elaborated on the innovation process, which can be seen in Figure 2.

The report of the project defines technology innovation as a continuous process but with several definable yet overlapping stages. Technology development, it is stated, aims at a specific goal, requiring investment and coordination at all stages. For successful outcomes and optimal use of resources, it would be necessary to engage both public and private sectors in technology innovation and development.

At the earliest stages of innovation, strengthening of fundamental sciences is critical for creating the necessary knowledge that leads to new technology innovation. Generally, the benefits of basic research are difficult to quantify when investment decisions in programmes of research are made. However, despite the riskiness of funding basic research, national governments continue to support activities in this field because scientific capabilities provide a springboard for

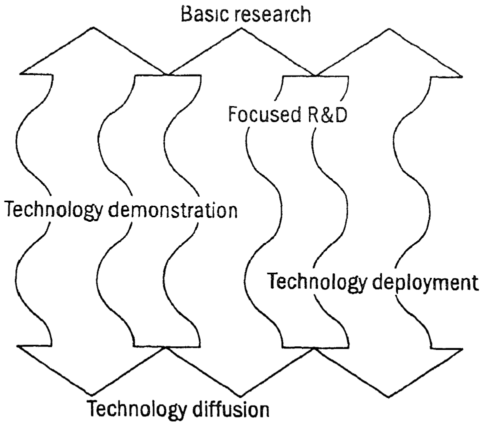


Figure 2 Innovation process
Source Battelle Memorial Institute (undated)

innovation that would have ultimate commercial and economic benefits. Interestingly, the Japanese government, even in periods of low economic growth or recession, continues to increase funding of basic research, based on the expectation that this would increase the technological opportunities for the country, providing it with a competitive edge in a world where technological innovations would essentially drive commercial and economic success.

The process of applied research generally targets a product or process that would bring about improvements in existing practice and reach certain desired goals which would have economic benefits. Currently, for instance, a number of major automobile manufacturers and other organizations are focusing on the development of fuel-cell technology, because this would provide a means for pollution-free transportation in the future. However, there is also enormous potential for fuel-cell technology for stationary applications. Unfortunately, power generation using stationary fuel cells does not appear to provide as attractive a market as transportation would in the developed world where access to electricity is not a major concern. Consequently, enough R&D is not being done on the use of fuel cells for stationary applications. In an area such as this, therefore, the governments of developing countries like India could provide some support to corporate organizations for undertaking focused and goal-oriented R&D to come up with products that would have a great demand in rural areas in particular.

Government subsidies for R&D and new product development can be used in efficient ways, so that market mechanisms are fully utilized and efficiency criteria fully met. For instance, in the US, the DoE (Department of Energy) has used an innovative approach for the development of energy-efficient household appliances. The method adopted, known as a 'buy down' arrangement, essentially relies on a request for proposals from potential manufacturers who may be asked, for instance, to develop and produce 100 000 units of a refrigerator manufactured to improved efficiency standards. The USDoE would then select the best bid and place an order for the manufacture of the required 100 000 units. These manufactured units would then be sold through normal marketing channels at prices existing in the market for currently sold refrigerators, which, of course, have lower levels of efficiency. Through this process and the implied subsidy, which represents the difference between the cost at which the efficient refrigerators were purchased and the prices at which they were sold, a foundation would be laid for further expansion of the market for efficient refrigerators. A similar approach could be followed in India, for instance, for the development of fuel cells for stationary applications by involving domestic manufacturers either solely or in partnership with organizations overseas.

It needs to be emphasized that innovation is an iterative process as brought out in the report of the Global Energy Technology Strategy project. In other words, success or failure in one stage of the innovation process could lead to renewed efforts in other stages by which alternatives and options can be created. There is also an important role for feedback from the market, by which improvements and refinements become possible, leading to superior products.

With increase in energy prices, different countries throughout the world would have a much stronger incentive to improve the efficiency at different stages of the energy cycle. After the oil price shock of 1973/74, global energy intensity started moving down significantly (Figure 3).

Projections up to the end of this century indicate a substantial decline in energy intensity as provided by a number of diverse scenarios. These changes would be the result of innovation across

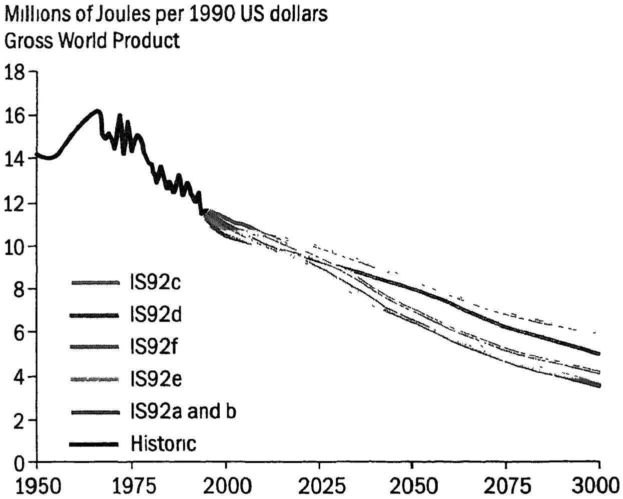


Figure 3 Global energy intensity
Source Battelle Memorial Institute (undated)

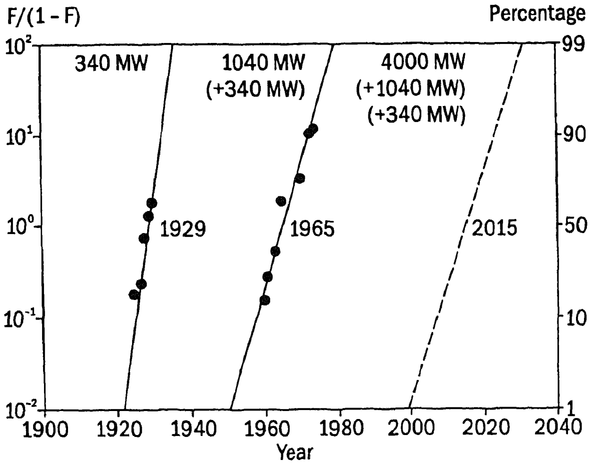


Figure 4 The maximum size of the US Power Plants
Note Each line represents an S-shaped (logistic) curve normalized to 100%, with estimates for the midpoint of the process and saturation level indicated. So, the pulse centred in 1929 quickly expanded power plants from a few tens of megawatt to about 340 MW. After a period in which plant size stagnated, the pulse centred in 1965 quadrupled maximum plant size to almost 1400 MW. The patterns for the world and a dozen other countries we have analysed closely resemble the US. Note the projection for another spurt in plant size centred around the year 2015, quadrupling the maximum again, to more than 5 GW. F is the fraction of the process completed.
Source World Electric Power Data CDROM UDI-2454, Utility Data Institute, Washington, DC, July 2000 as quoted in Ausubel (2001)

the board not only in the energy system of the global economy, but also in the economic structure for the production of goods and services. An example of technological innovation, created by increases in power plant size which have taken place over time, providing economies of scale and improvements in the efficiency of energy use, is shown in Figure 4.

Similar developments have taken place on the consumption side as well. For instance, the mainframe computers of the 1960s and 1970s have given way to miniaturized units that are now household items and literally in the nature of children's toys. Each one of these units consumes a mere fraction of the energy that was consumed by mainframe computers, which in several cases had lower computing power. Jesse H Ausubel refers to the evolution of computer chips wherein a new generation of this item replaces the old every two to three years almost as if, in his words 'programmed by robots in Silicon Valley'. He also refers to compact discs replacing cassettes, which in turn replaced long playing records and these of course replaced the old 78 RPM records. The result of these innovations has been a substantial reduction in material and energy used per unit. Of course, it is another matter that the market itself has grown so extensively that the reduction in material and energy use per unit is more than offset by the enhanced numbers now used throughout the world.

In the area of renewable energy technologies, several innovations appear promising at this stage, but perhaps the most widely referred to is the development of solar photovoltaic technology. An interesting computation carried out by the Global Energy Technology Strategy project shows that if solar power could be developed such that its cost would drop to 3 cents per kWh as against the current 9 cents, then the global costs of stabilizing atmospheric carbon dioxide levels at 550 PPM (parts per million) would be reduced by about 1.5 trillion dollars. This is an interesting means to show the huge pay-off to the global community from investments in development and cost reduction of photovoltaic cells. This makes a strong case, therefore, for major efforts at the global level for R&D on new technologies. The trend, however, from the mid-1980s to mid-1995 was in the direction of reduced R&D investments for energy. The break-up of global energy R&D investments in 1995 is shown in Figure 5.

To influence trends in energy production and consumption, it is not enough for innovation or technological change to take place within the energy sector alone. Changes that take place in the structure of the economy as a whole have profound impacts on energy decisions. For instance, if agriculture was to move towards the greater use of organic fertilizers or the use of seed material derived from research on modern biotechnology requiring lower quantities of chemical fertilizers, then to that extent, the consumption of energy for fertilizer production and transportation could be eliminated. Similarly, seeds that are developed with qualities of pest resistance can do away with the use of chemical pesticides with direct implications for energy production and use.

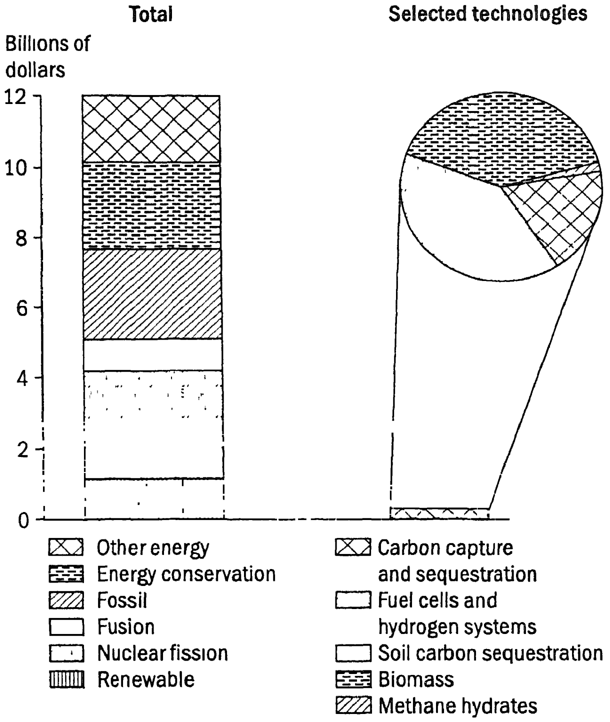


Figure 5 Global energy R&D investments in 1995
Source Battelle Memorial Institute (undated)

The transport sector is, of course, the most important area for innovation which has implications for energy use. After the oil price shocks of 1973/74 and 1979/80, most of Europe and Japan, for instance, invested heavily in the improvement of rail transport technology with consequent improvements in transportation efficiency and speed. It is needless to say that technology by itself in such cases will not achieve much, but there would also have to be matching investments in infrastructure to extend the use of improved technologies. In the case of the railways, the use of high-speed trains would require substantial improvements in and strengthening of rail capacity, improved telecommunications and signalling and other infrastructure that matches improvements in rolling stock technology. The spread of automobile transportation in the US, for instance, was the result of major investments in the creation of a modern highway infrastructure. Some of these investments would flow from the private sector, but most often there would be need for public support of such programmes if not direct investment by the government itself.

A technology strategy for the energy sector, therefore, has to be embedded in an overall technology strategy for the economy as a whole. The imperatives of giving technology an important place in India's energy decision-making are now much stronger, given the globalization of economic activities that India would be a part of. Competitive forces would require India to use its energy far more efficiently over the entire cycle of production, conversion, and consumption. Correspondingly, a long-term R&D strategy would need to be developed to serve a future technology strategy for the country.

It is a pity that in developing countries there is as yet no effort to develop a technology vision and strategy for the future. There may be benefits in groups of countries at similar stages of growth attempting such exercises on a collaborative basis, assisted if necessary by multilateral development organizations. It is also, perhaps, necessary for so-called advanced developing countries like India to take the initiative in this direction. But for this to happen a realization is necessary at policy-making levels of the significance of technology in the energy sector.

Bibliography

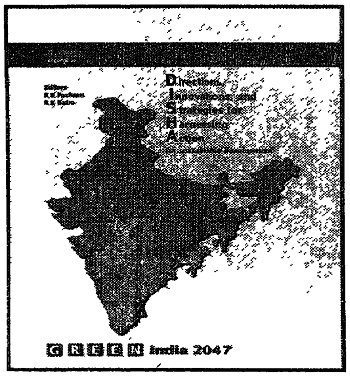
Ausubel J H. 2001
Some ways to lessen worries about climate change
The Electricity Journal **14**(1): 24–33

Battelle Memorial Institute. Undated
Global Energy Technology Strategy: addressing climate change
[Initial findings from an International Public–Private Collaboration]
[A document drafted by Jae Edmonds, Tom Wilson, and Richard Rosenzweig with substantive contributions from Richard Benedick, Elizabeth L Malone, John F Clarke, James J Dooley, and Son H Ki.]

Ausubel J H and Marchetti C. 2001
The evolution of transport
The Industrial Physicist 7(2): 20–24

Directions, Innovations, and Strategies for Harnessing Action
for sustainable development

Editors R K Pachauri and R K Batra



The state of India's natural resources in the first 50 years since independence was documented at length in TERI's *Looking Back to Think Ahead*, a 348-page volume. DISHA (Directions, Innovations, and Strategies for Harnessing Action): *for sustainable development*, its sequel, looks 50 years ahead, up to 2047. It is a substantial volume of 370 pages (42 figures, 111 tables, and 318 references), compiled by a team comprising over 30 researchers and guided by a panel of nine eminent reviewers.

Salient features
- Provides a detailed picture of the impact of development on the environment and natural resources over the second 50-year period from independence (1997 to 2047).
- Outlines specific elements of initiatives or actions.
- Lists major stakeholders who have to assume responsibility for correcting the aberrations of the past so that the future can be truly sustainable.

The chapters draw on the mistakes and lessons of the past as documented in *Looking Back to Think Ahead* and list the directions, innovations, and strategies required to achieve the alternative scenario in the sectors (power, coal, oil and gas, renewable energy, air, water, and land, including forests and biodiversity).

• Hardbound • 2001 • 370 pp • ISBN 81-85419-80-9 • Price Rs 950 (Indian); US $90 (overseas)

Contents
- Introduction
- Summary and scenarios
- Population and human development
- Environmental governance
- Climate change
- Corporate responsibility
- Market-based instruments
- The new technologies
- Agriculture
- Domestic and commercial sectors
- Municipal services
- Transport services
- Mining industry
- Manufacturing industries
- Power industry
- Coal
- Oil and gas
- Renewable energy
- Air
- Water
- Land, forests, and biodiversity

All orders and enquiries to

TERI
Information Dissemination Services
Darbari Seth Block, Habitat Place
Lodhi Road, New Delhi- 110 003

Fax +91 11 468 2144 or 468 2145
E-mail outreach@teri.res.in
Telephone +91 11 468 2100 or 468 2111
Web site www.teriin.org

Visit our online catalogue at www.teriin.org/pub/

Organization of the energy sector

Over the years, the Indian energy sector has been regulated and owned by government agencies and organizations. The basic institutional structure comprises a nodal ministry at the centre for each energy supply sector, which is the primary agency for policy formulation, support in decision-making, and implementation by state governments; state-level nodal agencies, public sector undertakings, and technical and research institutions. The dominant role of the union government in the energy sector can be traced to the Seventh Schedule of the Constitution of India, which provides a list of subjects reserved for the Union.

Energy-related subjects in the Seventh Schedule include

- atomic energy and mineral resources necessary for its production;
- regulation and development of oil fields and mineral oil resources, and petroleum and petroleum products;
- regulation of mines and mineral development as declared by the Parliament;
- regulation of labour and safety in mines and oil fields; and
- egulation and development of interstate rivers.

In addition, the Power and Energy Division of the Planning Commission looks after the Plan-related activities of the energy ministries. It also plays its own role in plans, policies and of course the process of formulation of five-year plans for these sectors.

States in India have had a limited role in the regulation, promotion, or conservation of atomic-, petroleum- or coal-based energy sources. Their involvement has been mainly in the electricity sector (the only energy-related subject in the concurrent list) and more recently in the promotion of NRSE (new and renewable sources of energy).

The organizational framework of the union government and related governmental agencies in the energy sector is depicted in Figure 1. A multitude of ministries, organizations, and agencies are vested with various functions geared towards ensuring sustainable energy development.

A brief description of the regulatory and organizational framework in each of the energy subsectors is given below.

Power

'Electricity' is a concurrent subject in the constitution of India, implying that both the Parliament and the State Legislature have the authority to legislate on the subject. The apex body for the power sector is the MoP (Ministry of Power) in the Government of India, which is mainly responsible for perspective planning, monitoring, and implementation of power projects. It also administers and enacts legislation pertaining to generation, transmission, and distribution of thermal power and hydropower. It undertakes amendments to these acts from time to time to reflect policy changes.

The Indian Electricity Act, 1910, the Electricity (Supply) Act, 1948; and the Electricity Regulatory Commission Act, 1998, provide the statutory framework for the regulation of electricity in India. There are also state-level legislations in the power sector in several states, including Andhra Pradesh, Haryana, Karnataka, Orissa, Rajasthan, and Uttar Pradesh.

The CEA (Central Electricity Authority) is a statutory organization constituted under the Electricity (Supply) Act, 1948. It advises the ministry on technical, financial, and economic matters. It also has the statutory function of giving concurrence to schemes involving capital expenditure beyond a certain limit as fixed by the government from time to time. The CEA is

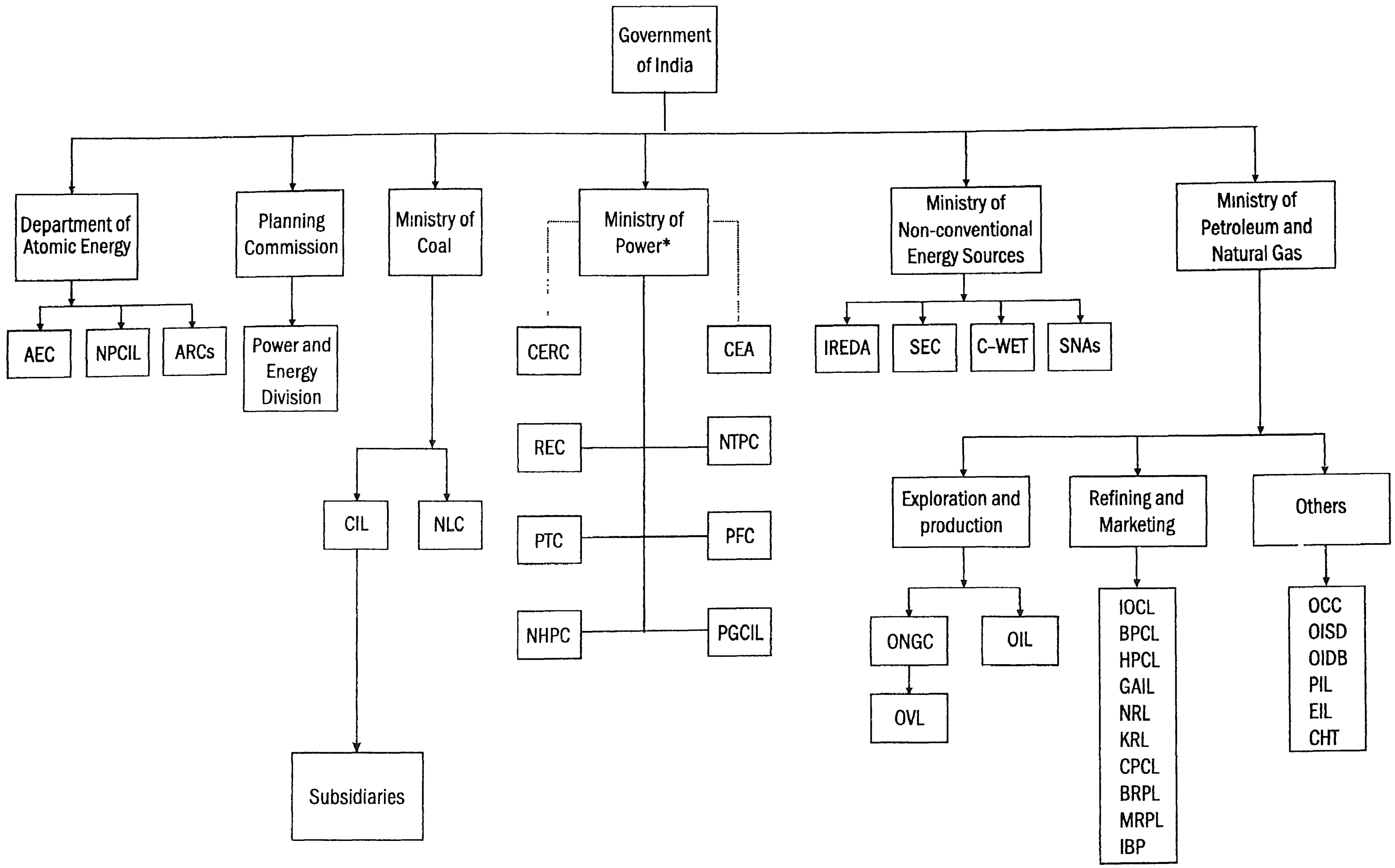


Figure 1 Organization of the energy sector

AEC - Atomic Energy Commission
ARCs - Atomic research centres
BPCL - Bharat Petroleum Corporation Ltd
BRPL - Bongaigaon Refinery and Petrochemicals Ltd
CEA - Central Electricity Authority
CERC - Central Electricity Regulatory Commission
CHT - Centre for High Technology
CIL - Coal India Ltd
CPCL - Chennai Petrochemicals Corporation Ltd
C-WET - Centre for Wind Energy Technology
EIL - Engineers India Ltd
GAIL - Gas Authority of India Ltd
HPCL - Hindustan Petroleum Corporation Ltd
IOCL - Indian Oil Corporation Ltd
IREDA - Indian Renewable Energy Development Agency
IBPL - Indo-Burma Petroleum Company Ltd
KRL - Kochi Refineries Ltd
MRPL - Mangalore Refinery and Petrochemicals Ltd
NHPC - National Hydroelectric Power Corporation
NLC - Neyveli Lignite Corporation
NPCIL - Nuclear Power Corporation of India Ltd
NRL - Numaligarh Refineries Ltd
NTPC - National Thermal Power Corporation
OCC - Oil Coordination Committee
OIL - Oil India Ltd
OIDB - Oil Industry Development Board
OISD - Oil Industry Safety Directorate
ONGC - Oil and Natural Gas Corporation
OVL - ONGC Videsh Ltd
PFC - Power Finance Corporation
PGCIL - Power Grid Corporation of India Ltd
PIL - Petroleum India International
PTC - Power Trading Corporation
REC - Rural Electrification Corporation
SEC - Solar Energy Centre
SNAs - State nodal agencies

* The state governments operate through SEBs (state electricity boards). Several state governments have also appointed SERCs (state electricity regulatory commissions)

also concerned with the development of a sound, adequate, and uniform power policy in relation to the control and utilization of national power resources.

The CERC (Central Electricity Regulatory Commission) constituted under the Electricity Regulatory Commissions Act, 1998, is an independent statutory body with quasi-judicial powers. Its main functions include the formulation of tariff policy and the framing of guidelines with regard to tariffs.

The REC (Rural Electrification Corporation) provides financial assistance for rural electrification programmes.

The NHPC (National Hydroelectric Power Corporation) plans, promotes, and operates hydroelectric power plants in the central sector.

The NTPC (National Thermal Power Corporation) is engaged in operating and setting up coal- and gas-based power projects in the central sector.

The PFC (Power Finance Corporation) is responsible for mobilizing capital from non-budgetary sources to provide term finance for power projects in the public and private sectors.

The PGCIL (Power Grid Corporation of India Ltd) is the main provider of extra high-voltage and high-voltage transmission networks in the country. It is responsible for all the existing and future transmission projects in the central sector and for the formation of the National Power Grid. It also functions as the central transmission utility and is currently concerned with regional grid operations as well.

The PTC (Power Trading Corporation) is an entity established to serve as a single point of contract for entering into power purchase agreements with independent power producers on the one hand and the consumers or state utilities on the other. Incorporated in 1999, it is jointly promoted by corporations including the PGCIL, the NTPC and the PFC. It mainly plays the role of a facilitator in the implementation of the government's mega power policy by limiting long negotiation processes. It also coordinates the offtake and sale of power from surplus regions to the deficit ones.

Other organizations in the power sector that come under the MoP include the NEEPCO (North Eastern Electric Power Corporation); the NJPC (Nathpa Jhakri Power Corporation), the THDC (Tehri Hydro Development Corporation), and two statutory bodies—the DVC (Damodar Valley Corporation) and the BBMB (Bhakra-Beas Management Board). The DVC was set up by an act of the central legislature in 1948 as the first multi-purpose river valley project in the country. It is engaged in promoting the integrated development of the Damodar Valley region, which falls in the states of Jharkhand and West Bengal. The BBMB administers, maintains, and operates the Bhakra Nangal hydro projects located in the states of Punjab and Himachal Pradesh.

At the state-level, SEBs (state electricity boards), constituted by the state governments, are responsible for ensuring supply, transmission, and distribution of electricity in the most economical and efficient manner. For this purpose, they are required to coordinate with the generating companies, if any, operating in the state and with the central government or any other board or agency that has control over a power system. Some states – Andhra Pradesh, Haryana, Karnataka, Orissa, Rajasthan, and Uttar Pradesh – have unbundled the SEBs along functional lines. In Orissa, the generation/distribution companies have also been privatized.

Several states have set up SERCs (state electricity regulatory commissions) and others are in the process of setting them up (details in the chapter on Power). The SERCs are engaged in regulating the purchase, distribution, supply, and utilization of electricity, quality of service, the tariff, and charges payable, considering the interests of both the consumer and the electricity industry in the state. Responsible for promoting competition, efficiency, and economy in the activities of the industry, the SERCs also aid and advise in matters concerning generation, transmission, distribution, and supply of electricity in the state.

The CPRI (Central Power Research Institute), set up to serve as a national laboratory for undertaking applied research in electric power engineering, also functions as an independent national testing and certification authority for ensuring the reliability of electrical equipment and components.

Coal

Under the Constitution of India, the power to regulate mines and mineral development lies with both the central government and the state governments. However, by the Mines and Minerals

(Regulation and Development) Act enacted by the Parliament in 1957, the administration of minerals classified in Schedule I is to be undertaken by the central government and that of other minor minerals by the states. Coal is listed in Schedule I and thus the development of coal resources is controlled by the central government.

The deregulation of coal prices became effective from 1 April 2000, with the Colliery Control Order, 2000. This supersedes the Colliery Control Order, 1945, of the Essential Commodities Act, 1955, by which the central government had been empowered to fix the prices of coal by grade and colliery.

The MoC (Ministry of Coal) is the primary body in the Government of India responsible for policy formulation with regard to coal and lignite resources in the country.

The CIL (Coal India Ltd) is the apex body for exploration, production, and distribution of coal and implementing policy guidelines developed by the MoC. It monitors the performance of its eight subsidiary companies and is involved in long-term planning, conservation, and R&D in mining. Seven of the CIL's subsidiaries, namely, the ECL (Eastern Coalfields Ltd), the BCCL (Bharat Coking Coal Ltd), the CCL (Central Coalfields Ltd), the NCL (Northern Coalfields Ltd), the WCL (Western Coalfields Ltd), the SECL (South Eastern Coalfields Ltd) and the MCL (Mahanadi Coalfields Ltd) are coal producing companies directly engaged in the raising and distribution of coal. The Central Mine Planning and Design Institute Ltd, a subsidiary of the CIL, is engaged in mine planning and designing in the coal sector, and also renders mining and engineering consultancy services.

The NLC (Neyveli Lignite Corporation) is entrusted with the exploration and production of lignite in Tamil Nadu, Rajasthan, Gujarat and Jammu and Kashmir. In Tamil Nadu, the NLC is also engaged in the generation of coal-based power.

The exploration and production of coal in Andhra Pradesh is carried out by another public sector undertaking in the coal sector, the SCCL (Singareni Collieries Company Ltd), which is a joint venture between the Government of Andhra Pradesh and the Government of India.

Petroleum and natural gas

The legal framework for the exploration and production of oil and gas is provided mainly by the Oilfields Development and Regulation Act, 1948, and the Petroleum and Natural Gas Rules, 1959. The Act was amended in 1999 to provide for the NELP (New Exploration Licensing Policy). The downstream sector is regulated mainly by the Indian Petroleum Act and a number of orders passed by the government under the Essential Commodities Act.

The MoPNG (Ministry of Petroleum and Natural Gas) oversees the entire chain of activities in the oil industry: exploration and production of crude oil and natural gas; refining, distribution, and marketing of petroleum products and natural gas; and exports and imports of crude oil and petroleum products.

Several organizations fall under the purview of the MoPNG.

The DGH (Directorate General of Hydrocarbons) was set up in 1993 under the administrative control of the MoPNG, with the objective of ensuring correct reservoir management practices, reviewing and monitoring exploratory programmes, development plans for national oil companies and private companies, and monitoring production and optimum utilization of gas fields.

The OCC (Oil Coordination Committee) currently performs the functions of planner, coordinator, adviser, and regulator in the downstream sector.

The exploration and production of natural gas in the country is primarily undertaken by ONGC (Oil and Natural Gas Corporation) Ltd and the OIL (Oil India Ltd). The ONGC has also set up a wholly-owned subsidiary, ONGC Videsh Ltd, to look after the company's overseas operations.

GAIL (Gas Authority of India Ltd) is responsible for transportation and marketing of natural gas. Set up in 1984, it now operates 4000 km of pipeline, including the 2702-km-long Hazira–Bijapur–Jagdishpur pipeline extending from the western coast to North India, and over 1300 km of pipeline in different states.

Other organizations in the Indian petroleum and natural gas sector include the Oil Industry Safety Directorate, which develops standards and codes for safety and fire fighting, training programmes, information dissemination, etc; the Oil Industry Development Board, which provides financial and other assistance for conducive development of the oil industry; the Engineers India Ltd, which provides engineering and consulting services to the petroleum industry; the Centre for High Technology, which coordinates and funds research work in refining and marketing; and the Petroleum India International, which provides technological and managerial expertise to companies abroad.

Additionally, there are various organizations in the downstream (marketing and refining) sector: the IOC (Indian Oil Corporation), the BPCL (Bharat Petroleum Corporation Ltd) and the HPCL (Hindustan Petroleum Corporation Ltd), the NRL (Numaligarh Refineries Ltd), the KRL (Kochi Refineries Ltd), the CPCL (Chennai Petrochemicals Corporation Ltd) and the BRPC (Bongaigaon Refineries and Petrochemicals Corporation) in the public sector; the MRPL (Mangalore Refinery and Petrochemicals Ltd) in the joint sector, and the RPL (Reliance Petroleum Ltd) in the private sector. The IBP (Indo-Burma Petroleum) Company Ltd is engaged only in the marketing of petroleum products.

Gas is marketed by smaller regional companies in India—by the Mahanagar Gas Ltd, a joint venture between GAIL and British Gas in Mumbai, Maharashtra; by Gujarat Gas Company in the cities of Surat, Bharuch, and Ankleshwar in Gujarat; by the Baroda Municipal Corporation in the city of Baroda, Gujarat; and by Indraprastha Gas Ltd, a joint venture between GAIL, BPCL, and the Government of the National Capital Territory of Delhi.

Renewable energy sources and technologies

The MNES (Ministry of Non-conventional Energy Sources) is primarily responsible for policy formulation, resource assessment, R&D, demonstration, commercialization, and large-scale utilization of NRSE (new and renewable sources of energy) such as biogas, biomass, solar energy, wind energy, small hydro power, improved *chulhas*, ocean energy, geothermal energy, alternative fuels, hydrogen, and draught animal power. Other important activities of the MNES include awareness creation, information dissemination for the popularization of non-conventional renewable energy devices and systems, and fostering cooperation for financial and technical assistance from multilateral and bilateral agencies. On the basis of end use of RETs (renewable energy technologies), the MNES has three broad sectoral groups: (1) rural energy, (2) urban and industrial energy, and (3) power generation. This structure has been designed keeping in mind the objective of promoting commercialization, market orientation, and private sector participation.

The Indian Renewable Energy Development Agency is the promotional, developmental, and financing arm of the MNES. Established in 1987, it falls under the administrative control of MNES and provides concessional finance and technical consultancy support for the promotion and development of renewable energy sources. It is also engaged in the promotion of energy efficiency and conservation projects and schemes.

The programmes of the MNES are implemented through state nodal agencies, SEBs, R&D institutions, industries, and non-governmental organizations. Since 1996, these programmes have been made more market-oriented, with a greater role for the private sector.

India's renewable energy programme derives strength from technical support provided by the SEC (Solar Energy Centre) and the C-WET (Centre for Wind Energy Technology). The SEC at Gual Pahari, near Delhi, is involved in the testing and standardization of solar energy devices and systems, R&D work, providing consulting services, as well as promoting the use of solar passive architecture—all activities geared towards ensuring enhanced use of solar energy. The role of C-WET at Chennai covers a wide range of wind-energy-related activities: R&D, technology upgradation, testing certification, standardization, training, and information dissemination.

Additionally, the SNAs (state nodal agencies), also known as energy development agencies, are responsible for propagating RETs, in tandem with the MNES, in their respective states. These agencies chalk out state-level programmes and plans for RETs. The subsidies and other support provided by the MNES are also channelled through SNAs. In addition to their own schemes, the SNAs also facilitate implementation of various schemes of the MNES.

Atomic energy

The AEC (Atomic Energy Commission), set up in 1948, controls all activities ensuring peaceful exploitation of nuclear energy. The AEC formulates policies for the DAE (Department of Atomic Energy), prepares its budgets, and ensures that policies are implemented. The Atomic Energy

Regulatory Board under the AEC is responsible for regulatory and safety functions.

The overall development, control, and use of atomic energy in India is guided by the Atomic Energy Act, 1962, which seeks to ensure that atomic energy activities are carried out keeping in mind the welfare of the people of India and for peaceful purposes. Other legislation on atomic energy relates to several issues including control of irradiation of food, radiation protection, and safe disposal of radioactive wastes.

The DAE, set up in 1954, is responsible for R&D, uranium exploration and production, fuel element design, and construction and operation of heavy water plants.

The Nuclear Power Corporation of India Ltd is a wholly-owned undertaking of the Government of India under the administrative control of the DAE. It undertakes the design, construction, operation, and maintenance of atomic power stations for the generation of electricity.

Atomic research centres in India include the Bhabha Atomic Research Centre, the Centre for Advanced Technology, the Indira Gandhi Centre for Atomic Research, and the Variable Energy Cyclotron Centre.

Indian energy sector: an overview

Introduction

India accounted for 12.5% of total primary energy consumption in the Asia-Pacific region and 3% of world primary energy consumption in 2000/01 (British Petroleum 2001). Per capita energy consumption remains low at 486 KGOE (kilograms of oil equivalent) compared with a world average of 1659 KGOE in 1998 (World Bank 2001). Increasing oil and coal imports in recent years is an area of concern for the Indian energy sector, with net energy imports increasing from 8% in 1980 to 13% in 1998 (World Bank 2001).

An encouraging sign for the sector is the declining energy intensity over the 1990s (Figure 1). In general, energy intensity first rises with economic growth and increases in energy consumption. Beyond a certain level of per capita income, energy intensity begins to decline. The decline in energy intensity in India has been accompanied with a levelling to an average of 0.02 TOE (tonnes of oil equivalent) per thousand rupees of GNP (gross national product) in the 1990s.

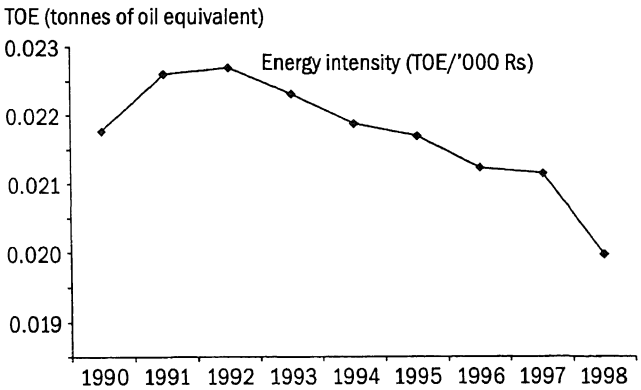


Figure 1 Energy intensity in India
Sources CCO (2000) (and earlier issues), MoPNG (2000), MoF (2001)

Energy supply

Coal dominates the energy mix in India, contributing 70% of the total primary energy production. The past few years have been marked by an increasing share of natural gas in primary energy production, from 10% in 1994 to 13% in 1999/2000. There has been a decline in the share of oil in primary energy production, from 20% to 17% in the same period. Trends in energy production in the past decade are shown in Figure 2.

Coal

Indian coal reserves comprise eight per cent of the world total (British Petroleum 2001). The country is the fourth largest producer of coal and lignite in the world (after the United States, China, and Australia) and accounted for seven per cent of total world production in 2000/01 (British Petroleum 2001).

The total coal production in 2000/01 was 309 MT (million tonnes) (Table I). Coal production is concentrated in five states (Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra,

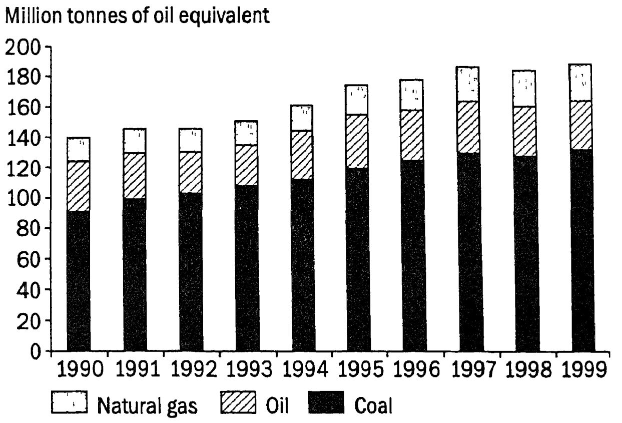


Figure 2 Energy production trends
Sources CCO (2000) (and earlier issues), MoPNG (2000)

Table I Energy supply indicators: 2000/01

Reserves / production	*Coal* (million tonnes)	*Oil* (million tonnes)	*Gas* (billion cubic metres)	*Power*
Reserves / installed capacity	213 905.5[a]	645	647	101 630 MW[d]
Production / generation	309	31.95[b]	28.45[c]	499.45 billion units

[a] Coal reserves up to a depth of 1200 metres, as on 1 January 2001.

[b] Figures are for 1999/2000, and include crude oil production only. Production of petroleum products was 79.42 million tonnes.

[c] Figures are for 1999/2000. Gross production includes flaring.

[d] Figure as on 31 March 2001.

Source MoPNG (2000)

and Orissa), which together made up 87% of the total production in 1999/2000 (CCO 2000).

Despite India's large reserves of coal, there has been an increase in coal imports, which have grown from 6 MT in 1991/92 to 20 MT in 1999/2000, a rate of growth of 16% a year (MoC 2001). Increasing imports call for measures to improve the productivity in coal mines and the quality of coal supplied.

Oil and gas

India is a net importer of crude oil and petroleum products, giving rise to energy security concerns and vulnerability to external price and supply fluctuations. Net imports of crude oil and petroleum products have more than doubled in the past nine years, from 27 MT in 1990 to 57 MT in 1999 (MoPNG 2000). These imports comprised 20% of the total value of Indian imports in 1999/2000.

Though about 41% of the Indian sedimentary basins still await exploration, balance recoverable reserves of crude oil in the country have been declining, falling from 806 MT in 1991 to 645 MT in 2000/01 (Table I). Crude production in 1999/2000 stood at 31.95 MT (MoPNG 2000). Reserves of natural gas also dropped between 1991 and 1999, from 730 billion cubic metres to 647 billion cubic metres, corresponding to a dramatic 52.5% increase in production.

Power

The all-India installed generating capacity under utilities, as on 31 March 2001 was 101 630 MW, comprising 71% thermal, 25% hydro, 3% nuclear, and 1% wind. Coal is the dominant fuel used in the power sector, contributing 60% of the total installed capacity. The bulk of total installed capacity (61%) was in the state sector, with the central sector accounting for 30% of the total installed capacity.

Capacity additions of 40 245 MW were initially planned for the Ninth Five-year Plan period (1996/97–2001/02), a target that was subsequently scaled down to half that amount. The actual capacity addition has fallen short of even this figure, resulting in overall energy and power shortages in the country. Energy shortages have been increasing in the past few years, from 5.9% in 1998/99 to 7.8% in 2000/01.

The dominant use of coal in the power sector has been associated with adverse environmental impacts. In this context, the optimum primary energy mix of power generation is a critical issue that needs to be addressed. Over the years, the balance between thermal and hydro electricity has tilted against hydropower. Special efforts are needed to restore the balance as the country's large water resources could be utilized to counter the problem of carbon emissions and to reduce peaking deficits (Planning Commission 2001).

Renewable energy

The production and use of fossil fuels for power generation, industrial production, and transportation has been associated with adverse local environmental impacts such as deforestation, land degradation, and water and air pollution. In addition, there are concerns about the release of GHG (greenhouse gas) emissions from the energy sector, particularly power generation using fossil fuels.

One strategy to address these environmental issues, and diversify sources of energy supply at the same time, is the development and promotion of technologies using renewable natural resources such as biomass, water, wind, and solar energy. The potential for expanding the use of RETs (renewable energy technologies) for energy generation in India is vast. As on 31 December 2000, the contribution of renewables has reached 3000 MW, which is three per cent of the total grid capacity. There remains vast potential for increasing the contribution of renewable energy to power generation, with the achieved wind power capacity just three per cent of the potential from this source. Similarly, the installed biomass power and small hydropower capacities are just two per cent and nine per cent of their potential, respectively (MNES 2001).

Energy consumption

The total final energy consumption in India is 202 MTOE (Table 1). This represents a growth of 5.5% a year over the period 1990–99. The steady rise in energy consumption over the past decade has been accompanied with changes in the relative share of different fuels (Figure 3). A spurt in oil consumption in 1999/2000 increased its share to 36% of total energy consumption, compared to an average share of 32% for 1990–99. Coal remains the dominant fuel at 55% of primary energy consumption at present.

Energy consumption by different economic sectors – agriculture, industry, transport, and residential – reveals the composition of fuels used in meeting energy needs in these sectors (Table II).

Table II Sectoral energy consumption by fuel (%): 1999/2000

Sector	*Coal*	*Natural gas*	*Petroleum products*	*Power*	*Total*
Agriculture	0	1.3	9.5	89.2	100
Industry	73.1	2.4	13.6	10.9	100
Transport	0	0	98.5	1.5	100
Residential	0	1.1	71.3	27.6	100
Others	0	33.9	60.9	5.2	100

Source TERI estimates

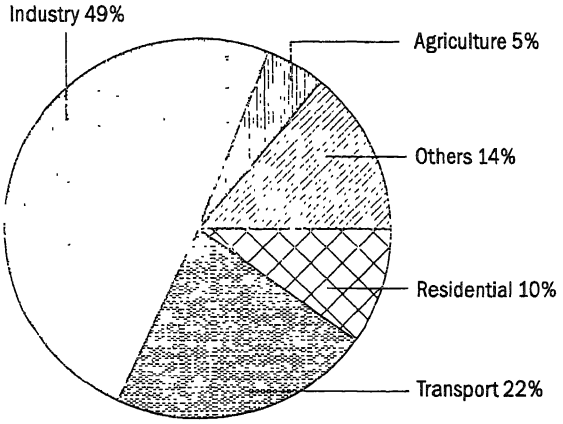


Figure 4 Sectoral composition of commercial energy consumption: 1999/2000
Source TERI estimates

The industrial sector is the largest consumer of energy, consuming about half of the total commercial energy consumption in 1999/2000 (Figure 4). Coal and lignite meet over half of industrial commercial energy requirements. The transport sector is the next biggest consumer at 22% of total commercial energy consumption.

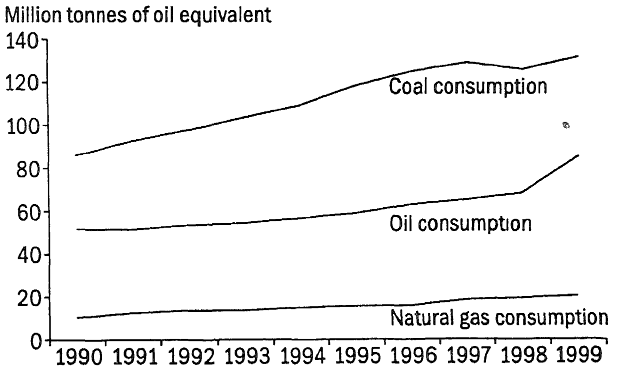


Figure 3 Energy consumption trends
Sources CCO (2000) (and earlier issues), MoPNG (2000)

Issues and concerns

While declining energy intensity of GDP indicates a favourable trend in the energy sector, several concerns remain such as energy security, environmental concerns, and energy-related implications for human health and well-being. An overview of these issues for the Indian energy sector is presented below.

Energy security

Imports of oil and coal have been increasing at rates of 7% and 16% per annum, respectively during the period 1991–99. This dependence on energy imports is projected to increase in the future. Estimates indicate that oil imports will meet

75% of total oil consumption requirements and coal imports will meet 22% of total coal consumption requirements in 2006 (TERI 2000). At present, India does not import any natural gas but demand is supply constrained and imports of gas and LNG (liquefied natural gas) are likely to arise in the coming years. This energy import dependence implies vulnerability to external price shocks and supply fluctuations, which threaten the energy security of the country.

Increasing dependence on oil imports means dependence on imports from the Middle East, a region susceptible to disturbances and consequent disruptions of oil supplies. This calls for diversification of sources of oil imports. The need to deal with oil price fluctuations also necessitates measures to be taken to reduce the oil dependence of the economy, possibly through fiscal measures to reduce demand and by developing alternatives to oil, such as natural gas and renewable energy. New technologies such as fuel cells for automobiles could provide an alternative for reducing oil consumption in the transport sector. Further, measures to develop alternative sources of energy such as coal gasification could improve energy security by utilizing domestic coal reserves and providing a competitive alternative to imported natural gas. The adoption of improved technologies such as IGCC (integrated gasification combined cycle technology) and PFBC (pressurized fluidized bed combustion) would also increase the efficiency of coal utilization, which would reduce import requirements.

Environmental concerns

Energy production and utilization involves a disturbance to the state of the environment. Coal exploration and mining causes land degradation through subsidence and mine fires. The impact of mining on forest areas is of particular concern as there is considerable overlap between forests and coal reserves in India. Similarly, oil and gas exploration and production poses a threat to the existing physical, chemical, and the biological status of the environment. The major concerns associated with onshore oil and gas production are drilling waste fluids, drilling waste solids, produced water and volatile organics (TERI 2001), which can contaminate surrounding water bodies.

The utilization of fuels in the power, transport, and industrial sectors is associated with visible and adverse environmental impacts. One of the most significant problems is the generation of fly ash during the combustion of coal in power generation. In India with over 60% of power generation being coal-based and the inherently high ash content of indigenous coal (more than 40% in some cases), 80–100 million tonnes of fly ash are produced every year. India stands second only to China in the quantum of fly ash generated every year. Currently, nearly 90% of fly ash generated is dumped as slurry in ash ponds, which requires huge amounts of water, results in creation of wasteland and could also lead to leaching of heavy metals and soluble salts. Leakage from ash ponds to neighbouring fields and water bodies can lead to surface and groundwater pollution. The utilization of fly ash in India remains low at 10%, compared with utilization rates of 30%–100% internationally (Kumar 2000).

The energy and resource intensity of industrial production coupled with low resource use efficiency has caused environmental deterioration in areas where industrial units are located. The highest concentration of sulphur dioxide and oxides of nitrogen is found in cities in states where the bulk of industrial units is located (CSO 1999). Seven resource-intensive and highly polluting industries (copper, aluminium, steel, cement, fertilizers, textiles, and PVC [polyvinyl chloride]) are a major source of SPM (suspended particulate matter) emissions in the country. Industrial units located in densely populated urban areas discharge untreated effluents into surface water channels, land sites, and sewers. It is estimated that industrial activities contribute more than one-third of the total pollution in rivers and water bodies. About 1532 grossly polluting industries discharge effluents into water courses.

The use of gasoline and diesel in the transport sector generates a number of pollutants like lead, carbon monoxide, toxic compounds such as benzene, and particulate matter which are discharged to the atmosphere alongwith vehicular exhaust gas (CPCB 2000). The transport sector is the largest consumer of commercial energy next to industry. A combination of factors including increased travel demand, dominance of road based and personalized modes of transport and fuel combustion in inefficient vehicular technologies has resulted in air pollution in urban areas reaching critical levels. Of particular concern is the level of concentration of carbon monoxide and particulate matter. Data indicate that SPM levels are critical in 21 areas in the country (CPCB 2000).

In addition to these local environmental impacts, the use of fossil fuels in energy combustion, transport, and industrial processes is a source of carbon dioxide emissions, which contribute to climate change. Fuel combustion in energy and transformation industries accounted for 87% of total carbon dioxide emissions in India in 1990. Although carbon dioxide emissions per capita in India are very low (1.1 tonnes) compared with the world average (4.1 tonnes) (World Bank 2001), these concerns should be addressed in energy policies.

Socio-economic dimensions: energy and quality of life

The production and use of energy also has important social dimensions, several of which are linked to the environmental implications discussed above. For instance, runoff from waste dumps that surround mines sometimes silts streams that are used for irrigation; or affects croplands, reducing their productivity. Energy projects at the construction stage, like most other construction projects – increase the risk of accidents and spread of communicable diseases from lack of sanitation or respiratory problems due to dust or fumes. Other social problems include displacement of people at the project site and perpetuation of slums once the construction is over.

Mining and energy projects, such as mega power projects, also sometimes necessitate clearing of forest lands. With increased deforestation, local fuelwood supplies get scarce. Women, who are primarily responsible for fuelwood collection in villages then have to make longer journeys with heavier loads of fuelwood, running the risks of problems such as spinal column damage (UNFPA 2000). Time spent for collecting wood and other household chores often leaves little time for productive employment, education, and community involvement.

At the consumption end too, energy has important implications for people at large, being central to the satisfaction of basic needs including health and nutrition. Energy use patterns have important health implications. Highly polluting fuels such as firewood, cow dung, and agricultural residue meet over 95% of the energy needs of Indian rural households. Combustion of these fuels leads to emissions of pollutants such as SPM, carbon monoxide, nitrogen dioxide, formaldehyde, and polyaromatic hydrocarbons (like benzopyrene). These pollutants cause acute respiratory infections, chronic obstructive pulmonary disease, lung cancer, tuberculosis, asthma, eye irritation, and blindness.

Smoke from wood and other biomass fuels used for household cooking may be responsible for up to 50% of total human exposure to particulate matter in the air (Smith and Thorneloe 1992). It is estimated that about five to six per cent of the national burden of disease in women and young children can be attributed to the use of biomass fuels in households (Holdren and Smith 2000).

The way forward

It is apparent that all elements of the energy cycle (production, collection, processing, and combustion) have important environmental and social ramifications. Access to modern energy forms such as electricity has a huge potential to alleviate poverty and improve the quality of life, particularly of those in remote rural areas. Energy could act as a crucial input for other infrastructure, facilitating the provision of piped water, streetlighting, and improved health care and education facilities.

Several factors hinder the provision of access to efficient and less polluting forms of energy and these stumbling blocks may be overcome by a mix of policy, institutional, and technological tools. The chapters in this publication study specific concerns and initiatives undertaken in various energy sub-sectors.

References

British Petroleum. 2001
BP Statistical Review of World Energy. June 2001.

CCO (Coal Controller's Organization). 2000
Coal Directory of India
Kolkata: CCO, Ministry of Coal, Government of India.

CPCB (Central Pollution Control Board). 2000
Transport fuel quality for year 2005
New Delhi: CPCB.

CSO (Central Statistical Organisation). 1999
Compendium of Environment Statistics
New Delhi: CSO.

Holdren J P and Smith K R (convening lead authors). 2000
Energy, the environment and health
(In Chapter 3 of J Goldemberg et. al., World Energy Assessment: energy and the challenge of sustainability)
New York: United Nations Development Programme/ Commission on Sustainable Development/World Energy Council

Kumar V. 2000
Barriers and Utilization Options for Large Volume Application of Fly Ash in India
New Delhi: Sycom Projects Consultants Private Limited (in association with Fly Ash Mission, TIFAC, National Thermal Power Corporation, and National Energy Technology Laboratory).

MoPNG (Ministry of Petroleum and Natural Gas). 2000
Basic Statistics on Indian Petroleum and Natural Gas
New Delhi: MoPNG, Government of India.

MNES (Ministry of Non-conventional Energy Sources). 2001
Renewable Energy in India: Business Opportunities
New Delhi: MNES, Government of India.

MoC (Ministry of Coal). 2001
Annual Report 2000/01
New Delhi: MoC, Government of India.

MoF (Ministry of Finance). 2001
Economic Survey 2000/01
New Delhi: MoF, Government of India.

Planning Commission. 2001
Draft Approach to the Tenth Five-year Plan (2002–07)
New Delhi: Planning Commission, Government of India.

Smith K R and Thorneloe S A. 1992
Household fuels in developing countries: global warming, health, and energy implications
Paper prepared for the *1992 Greenhouse Gas Emissions and Mitigation Research Symposium*, Washington, DC.

TERI (Tata Energy Research Institute). 2000
India's energy security
New Delhi: TERI

TERI (Tata Energy Research Institute). 2001
State Environmental Action Plan (SEAP), Gujarat: energy sub-component (Phase I Report)
Prepared for the Gujarat Ecology Commission
New Delhi: TERI.

UNFPA (United Nations Population Fund). 2000
Population and forests: a report on India, 2000
New Delhi: UNFPA.

World Bank. 2001
World Development Indicators 2001
Washington, DC: The World Bank

Table 1 Commercial energy balance (million tonnes of oil equivalent): 1999/2000

	Primary energy					*Secondary energy*													
Supply-demand and sources	*Coal and lignite*	*Oil*	*Natural gas*	*Hydro*	*Nuclear*	*Soft coke*	*Liquefied petroleum gas*	*Naphtha*	*Motor gasoline*	*Aviation turbine fuel*	*Kerosene*	*High speed diesel*	*Light diesel oil*	*Fuel oil*	*Other petroleum products*	*Total petroleum products*	*Thermal power*	*Total power*	*Total energy*
Supply																			
Production	132.05	31.95	24.37	6.79	1.12	–	–	–	–	–	–	–	–	–	–	–	–	7.91	196.29
Imports	12.67	56.90	–	–	–	–	1.56	0.26	0	0	5.74	5 60	0	0.48	0.06	13.69	–	–	70.48
Exports	0.04	–	–	–	–	–	0.04	0.23	0	0	0	0.29	0	0.03	0 33	0.91	–	–	0.95
Stock changes	–1.82	2.89	–	–	–	–	–0.23	0.15	0.35	0.10	0.67	0.70	0.12	–4.48	6 30	3.67	–	–	4.73
Availability	146.50	85.96	24.37	–	–	–	1.75	–0.12	–0.35	–0.10	5.07	4.61	-0.12	4.93	–6.57	9.11	–	–	261.08
Conversion	76.20	85.96	11.88	–	–	–	5.06	8.78	6.67	2.44	5.99	35.73	1.47	4.56	11.06	81.76	59.43	67.00	72.40
Soft coke	0	–	–	–	–	0.0019	–	–	–	–	–	–	–	–	–	–	–	–	0.002
Petroleum refining	–	85.96	–	–	–	–	2.81	8.78	6.67	2.44	5.99	36.01	1.68	6.46	11 06	81.91	–	–	4.06
Liquefied petroleum gas extraction	–	–	2.25	–	–	–	2.25	–	–	–	–	–	–	–	–	2.25	–	–	–
Power generation	76.20	–	8.30	6.79	1.12	–	–	–	–	–	–	0.28	0.21	1 90	–	2 39	86.89	94.80	94.80
Conversion losses in power generation	49.98	–	5.39	–	–	–	–	–	–	–	–	0.16	0.12	1.08	–	1.37	56.73	56.73	56.73
Auxiliary consumption in power station	2.36	–	0.25	0.06	0.12	–	–	–	–	–	–	0	0 01	0 07	–	0.09	2 69	2.87	2 87
Transmission and distribution losses	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7.39	7.39
Flaring natural gas	–	–	1.34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.34
Net availability	70.31	0	12.49	–	–	0.002	6.81	8.67	6.32	2.34	11.06	40.34	1.35	9.49	4.48	90.87	27.46	27.80	201.47
Consumption	70.31	0	12.49	–	–	0.002	6.81	8.67	6.32	2.34	11.06	40.34	1.35	9.49	4.48	90.87	–	27.80	201.47
Agriculture	–	–	0.13	–	–	–	–	–	–	–	–	0.61	0.05	0.34	–	1.00	–	9.36	10.49
Industry	70.30	–	2.27	–	–	–	1.12	–	–	–	–	3.25	0.82	7.89	–	13.09	–	10 51	96.17
Transport	0.01	–	–	–	–	–	–	–	6.32	2 34	–	35.17	0 07	0.30	–	44.20	–	0.67	44.88
Residential	–	–	0.23	–	–	0.002	5.59	–	–	–	9.29	–	–	–	–	14.88	–	5 75	20.86
Other energy uses	–	–	–	–	–	0	0.10	–	–	–	1.77	1.30	0.41	0.97	–	4.55	–	1.52	6.07
Non-energy uses	–	–	9.85	–	–	–	–	8.67	–	–	–	–	–	–	4.48	13.15	–	0	23.00

Note

Hydro and nuclear power are computed in energy equivalent (not in primary energy equivalent); Figures may not add up to total due to rounding-off.

Source

Compiled by TERI, New Delhi.

For more details, please see TEDDY ONLINE+ [Section: Economy (linkage with energy)]

Table 2 Commercial energy balance (million tonnes of oil equivalent): 1998/99

	Primary energy					*Secondary energy*													
Supply-demand and sources	*Coal and lignite*	*Oil*	*Natural gas*	*Hydro*	*Nuclear*	*Soft coke*	*Liquefied petroleum gas*	*Naphtha*	*Motor gasoline*	*Aviation turbine fuel*	*Kerosene*	*High speed diesel*	*Light diesel oil*	*Fuel oil*	*Other petroleum products*	*Total petroleum products*	*Thermal power*	*Total power*	*Total energy*
Supply																			
Production	127.67	32.72	23.50	6 27	0.84	–	–	–	–	–	–	–	–	–	–	–	–	7.11	191.00
Imports	10.15	39.81	–	–	–	–	1.72	0.45	0	0	6.09	10.85	0	0.51	0.01	19.63	–	–	51.40
Exports	0.44	–	–	–	–	–	0.03	0.69	0	0	0	0.27	0	0.09	0.37	1.44	–	–	1.88
Stock changes	−0.57	3.99	–	–	–	–	0.05	−1.09	0.07	0 20	0 61	0.06	0.08	−4.12	−1.53	−5 67	–	–	−2.25
Availability	**137.94**	**68.54**	**23.50**				**1.65**	**0.86**	**−0.07**	**−0.20**	**5.48**	**10.53**	**−0.08**	**4.53**	**1.17**	**23.86**	–	–	**242.77**
Conversion	**70.66**	**68.54**	**11.61**	–	–	–	**4.03**	**6.54**	**5.96**	**2.44**	**5.58**	**27.37**	**1.21**	**4.50**	**8.71**	**66.34**	**55.39**	**62.37**	**65.85**
Soft coke	0	–	–	–	–	0	–	–	–	–	–	–	–	–	–	–	–	–	0
Petroleum refining	–	68 54	–	–	–	–	1.95	6.54	5.96	2.44	5.58	27 65	1.38	6.31	8.71	66.53			2.01
Liquefied petroleum gas extraction	–	–	2 08	–	–	–	2 08	–	–	–	–	–	–	–	–	2.08			
Power generation	70.66	–	8.06	6.27	0 84	–	–	–	–	–	–	0.28	0.18	1 81	–	2.27	80.99	88.10	88.10
Conversion losses	46.36	–	5.23	–	–	–	–	–	–	–	–	0 16	0.10	1.03	–	1.29	52.88	52.88	52.88
Auxiliary consumption in power station	2.19	–	0 24	0 05	0.09	–	–	–	–	–	–	0	0.01	0.07	–	0.08	2.51	2.66	2.66
Transmission and distribution losses	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6.84	6.84
Flaring natural gas	–	–	1 47	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.47
Net availability	**67.28**	**0**	**11 89**	–	–	**0**	**5.68**	**7.39**	**5.90**	**2.23**	**11.06**	**37.90**	**1.13**	**9 04**	**9.88**	**90.20**	**25.60**	**25.73**	**195.10**
Consumption	**67.28**	**0**	**11.89**	–	–	**0**	**5.68**	**7.39**	**5.90**	**2.23**	**11.06**	**37.90**	**1.13**	**9 04**	**9.88**	**90.20**	–	**25.73**	**195.10**
Agriculture	–	–	0 14	–	–	–	–	–	–	–	–	0.57	0.04	0.33	–	0.93	–	8.66	9.73
Industry	67.27	–	2.78	–	–	–	0 94	–	–	–	–	3 06	0.68	7.51	–	12.19	–	9.73	91.96
Transport	0.01	–	–	–	–	–	–	–	5.90	2 23	–	33.03	0.06	0.28	–	41.50	–	0.62	42.13
Residential	–	–	0.18	–	–	0	4.66	–	–	–	9 29	–	–	–	–	13.95	–	5.32	19.44
Other energy uses	–	–	–	–	–	0	0.09	–	–	–	1 77	1.24	0 34	0.92	–	4.36	–	1.40	5.76
Non-energy uses	–	–	8.80	–	–	–	–	7.39	–	–	–	–	–	–	9.88	17.28	–	0	26.08

Note

Hydro and nuclear power are computed in energy equivalent (not in primary energy equivalent), Figures may not add up to total due to rounding-off

Source

Compiled by TERI, New Delhi.

For more details, please see TEDDY ONLINE+ [Section: Economy (linkage with energy)]

Table 3 Commercial energy balance (million tonnes of oil equivalent): 1997/98

	Primary energy					*Secondary energy*													
Supply-demand and sources	*Coal and lignite*	*Oil*	*Natural gas*	*Hydro*	*Nuclear*	*Soft coke*	*Liquefied petroleum gas*	*Naphtha*	*Motor gasoline*	*Aviation turbine fuel*	*Kerosene*	*High speed diesel*	*Light diesel oil*	*Fuel oil*	*Other petroleum products*	*Total petroleum products*	*Thermal power*	*Total power*	*Total energy*
Supply																			
Production	129.63	33.86	22.62	6.28	0.85	–	–	–	–	–	–	–	–	–	–	–	–	7.13	193.24
Imports	11.17	34.49	–	–	–	–	1.23	0.36	0	0.06	3.98	14.57	0	0.14	0.02	20.36	–	–	48.68
Exports	0.06	–	–	–	–	–	0.02	1.51	0	0	0	0.25	0	0.35	0.89	3.02	–	–	3.08
Stock changes	–0.20	3.18	–	–	–	–	–0.08	–0.51	–0.36	0.10	0.66	1.16	0.02	–4.36	–2.78	–6.14	–	–	–3.16
Availability	140.95	65.17	22.62	–	–	–	1.28	–0.64	0.36	–0.04	3.32	13.16	–0.02	4.14	1.91	23.48	–	–	242.00
Conversion	70.74	65.17	10.98	–	–	–	3.89	6.56	5.19	2.29	7.00	23.88	1.09	4.54	8.13	62.58	55.18	62.15	65.75
Soft coke	0	–	–	–	–	0	–	–	–	–	–	–	–	–	–	–	–	–	0
Petroleum refining	–	65.17	–	–	–	–	1.88	6.56	5.19	2.29	7.00	24.17	1.29	6.67	8.13	63.18	–	–	1.98
Liquefied petroleum gas extraction	–	–	2.01	–	–	–	2.01									2.01	–	–	
Power generation	70.74	–	7.36	6.28	0.85	–	–	–	–	–	–	0.29	0.20	2.13	–	2.62	80.72	87.84	87.84
Conversion losses	46.40	–	4.78	–	–	–	–	–	–	–	–	0.17	0.11	1.21	–	1.49	52.67	52.67	52.67
Auxiliary consumption in power station	2.19	–	0.22	0.05	0.09	–	–	–	–	–	–	0	0.01	0.08	–	0.09	2.50	2.65	2.65
Transmission and distribution losses	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6.83	6.83
Flaring of natural gas, etc			1.61	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.61
Net availability	70.21	0	11.64	–	–	0	5.18	5.92	5.54	2.25	10.32	37.04	1.08	8.68	10.04	86.05	25.54	25.69	193.59
Consumption	70.21	0	11.64	–	–	0	5.18	5.92	5.54	2.25	10.32	37.04	1.08	8.68	10.04	86.05	–	25.69	193.59
Agriculture	–	–	0.11	–	–	–	–	–	–	–	–	0.55	0.04	0.29	–	0.88	–	8.65	9.63
Industry	70.17	–	2.82	–	–	–	0.87	–	–	–	–	3.02	0.64	7.24	–	11.77	–	9.71	94.47
Transport	0.03	–	–	–	–	–	–	–	5.54	2.25	–	32.19	0.07	0.31	–	40.36	–	0.61	41.01
Residential	–	–	0.19			0	4.23	–	–	–	8.67	–	–	–	–	12.90	–	5.31	18.40
Other energy uses	–	–	–	–	–	0	0.08	–	–	–	1.65	1.27	0.33	0.84	–	4.18	–	1.40	5.58
Non-energy uses	–	–	8.53	–	–	–	–	5.92	–	–	–	–	–	–	10.04	15.97	–	0	24.49

Note

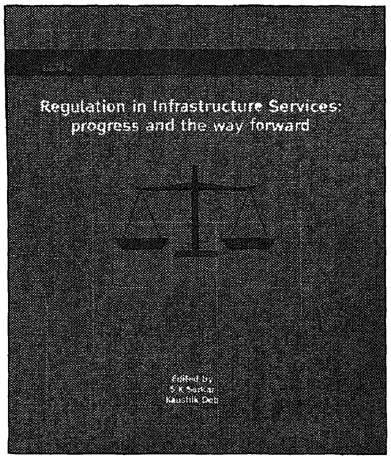
Hydro and nuclear power are computed in energy equivalent (not in primary energy equivalent); Figures may not add up to total due to rounding-off.

Source

Compiled by TERI, New Delhi.

For more details, please see TEDDY ONLINE+ [Section: Economy (linkage with energy)]

Regulation in Infrastructure Services: progress and the way forward


Regulation in Infrastructure Services: progress and the way forward
Edited by
S K Sarkar
Kaushik Deb

In South Asia, independent regulation of infrastructure sectors is a new concept and has thrown many challenges before the stakeholders during the transition from a monopoly to a competitive environment in these sectors. Regulation in infrastructure services has many dimensions. Its different facets, though they vary widely across sectors or across countries, converge on some core issues: consumer protection, need for financial viability in the sector, and provision of quality service.

This book examines the different aspects of regulatory development not only in India, but in other parts of the world too, bringing out their complexity, and making recommendations for future progress. It carries the views of several Indian and international experts on this subject. It hopes to serve as a ready reference for various issues in regulation in India's infrastructure sectors.

Contents

PART I INDEPENDENT REGULATION

• Framework for independent regulation in India: an overview • Role of independent regulation in economic reforms • The regulatory framework: experiences and issues • Establishing effective regulation: South Asia's challenges • Recent initiatives in developing regulatory framework in Gujarat's water sector

PART II TARIFF SETTING

• Tariff setting in the electric power sector: the Indian case study • Tariff setting in the privatized British electricity industry • The Argentinian electric power pricing system • Uncertainty, tariffs, and transmission and distribution losses • Transmission and distribution losses in India • Demand forecasting for electricity: the Indian experience • Demand forecasting in the new regulated energy scenario: the Brazilian electrical sector experience and challenges • Tariff-setting in telecommunications in India: progress to date and the way forward • Tariff setting in the telecom sector • Tariff setting in the water sector: the Chennai experience • A framework for tariff setting in the water sector: an overview • Port tariffs in India: an overview • Tariff setting in the port sector: major issues

PART III OTHER REGULATORY ISSUES

• Quality of service • Regulatory process • Consumer concern • Competition • Capacity building • Regulatory response to crisis

PART IV PATHS FORWARD

• The way forward • Conclusions and policy recommendations

Hardbound • 2001 • 490 pp • ISBN 81-85419-88-4 • Price Rs 920 / US $50

All orders and enquiries to

TERI
Information Dissemination Services
Darbari Seth Block, Habitat Place
Lodhi Road, New Delhi – 110 003

Fax +91 11 468 2144 or 468 2145
E-mail outreach@teri.res.in
Telephone +91 11 468 2100 or 468 2111
Web site www.teriin.org

VISIT OUR ONLINE CATALOGUE AT WWW.TERIIN.ORG/PUB/

ENERGY SUPPLY

Coal and lignite

At a glance

- India is the fourth largest producer of coal in the world, with total coal reserves of 213 905 MT (million tonnes) (as on 1 January 2001) of which proven reserves are around 84 414 MT. Lignite reserves in the country are estimated at 34 168 MT.
- Coal is one of the primary sources of energy, accounting for about 67% of the total energy consumption in the country.
- About 97% of the country's total coal production is attributed to national coal companies, of which Coal India Ltd accounts for 87% and the Singareni Collieries Company Ltd for 10%.
- India has substantial reserves of coal, but the quality of coal in terms of calorific value and ash content has deteriorated over time with an increase in opencast mining.
- Owing to the limited scope of coal benefication in India, imports serve as the next best option for the users of prime coking coal. Import of non-coking coal has gained prominence on grounds of transportation logistics as well as export entitlements. Total coal imports in 2000/01 were around 21.56 MT.
- Although there have been considerable improvements in the productivity levels (in terms of output per person shift) in the past, India still has a long way to go to be competitive internationally.
- A recent initiative towards reforming the sector has been the constitution of the Expenditure Reforms Commission.
- The Coal Mines (Nationalisation) Amendment Bill, 2000, allowing for private coal mining for non-captive use has been introduced in the Parliament.

Reserves and production

The Geological Survey of India has estimated India's proven coal reserves at 84 414 MT (million tonnes), which is approximately 8% of the total world proven reserves as on 1 January 2001. India's total coal reserves are estimated at 213 905 MT of which nearly 86% is non-coking coal reserves (Tables 1.01 and 1.02) (MoC 2000).

Lignite reserves in the country have been estimated at 34 168 MT. Of this 30 119 MT are in Tamil Nadu and Pondicherry, the rest in Gujarat and Rajasthan, with small quantities in Kerala and Jammu and Kashmir (Table 1.03).

India is the fourth largest producer of coal in the world. The CIL (Coal India Ltd) and its subsidiaries are the major producers of coal, contributing to approximately 87% of the coal produced in India. Through a sustained programme of investment and greater emphasis on the application of modern technologies, it has been possible to raise the production of coal to 309 MT[1] in 2000/01 as compared to 100 MT in 1975/76 (Table 1.05).

[1] Provisional data from the Coal Controller Organization, Ministry of Coal

However, alongside this increase in domestic coal production is the increasing demand for coal imports. This trend underlines the importance of addressing issues regarding coal exploitation technologies, quality of coal mined, adequacy of environmental and resource-utilization policies, and the legislative framework for the sector.

Location and quality of resources

The major coalfields of the country are situated in Assam, Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Orissa, West Bengal, and parts of Uttar Pradesh.

Coal exists predominantly in thick seams (approximately 70% of coal reserves are locked up in seams over 3.5 m thick; of this, 58% is in seams over 5 m thick) interbanded with extraneous matter. These seams are also complex with a multiplicity of coal horizons (20–25 m in Jharia, 30–36 m in Karanpura and 10 m in Raniganj).

Since some of the major consumption sites in India are located unfavourably in relation to the reserves, an enormous burden is placed on the transport infrastructure (Map 1).

The best quality of metallurgical coal is found in the mines of Jharia (Bihar) and in some mines in Raniganj (West Bengal). Before nationalization, mines in these areas were subjected to large-scale indiscriminate exploitation. As a result, the area is heavily built-up, and millions of tonnes of good quality coal has been left in pillars. Large areas of the Jharia and Raniganj mines have fires raging in them. Mining coal in these areas is therefore complicated, and the production of coal has steadily declined over the past several years.

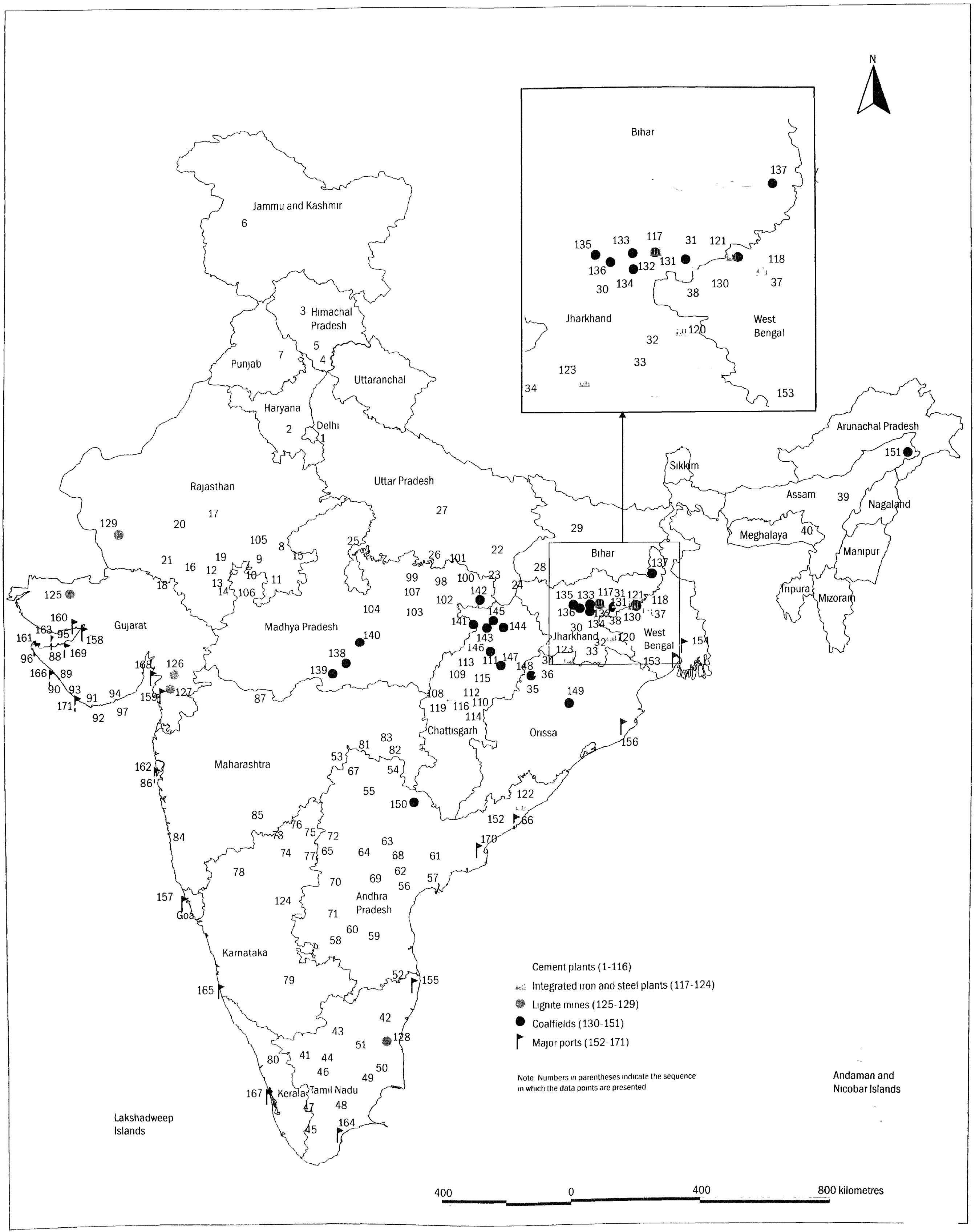
The potential areas with good quarriable prospects are located in East Bokaro, South Karanpura, and Sohagpur coalfields for metallurgical coal; Birbhum, Sohagpur, Mand–Raigarh, Tatapani–Ramkola, and Korba coalfields for superior grade non-coking coal; and Talcher, Korba, Rajmahal, and Auranga coalfields for inferior grade non-coking coal.

Coal beneficiation

Reserves of coking coal in the country are limited, and only two to three per cent of the total coal reserves fall into the prime coking category. Most of the coking coal is found in Bihar. The coal in Jharia has the highest coking property, although the ash content is inherently high at 21%. After suitable beneficiation, this coal, referred to as prime coking coal, can be used to produce coke of the prescribed quality required by steel plants. Coking coal in other coalfields can yield suitable coke only when blended with prime coking coal, and is termed medium coking coal.

Most of the washing plants for coking coal in India are old and have a low unit capacity. Of the 20 washeries currently in operation, only one has an annual output of over 1 MT of washed coking coal and three have individual outputs of less than 300 000 tonnes a year. Capacity utilization in coking coal washeries has been declining and stood at 47% in 2000/01. The details of raw coal feed and clean coal production by washeries are given in Table 1.17. Two of the washeries, Kargali and Giddi, have recently been converted to wash non-coking coal. The CIL has been having problems in maintaining its contractual obligations relating to a 17% maximum ash content in the coking coal supplied to SAIL (Steel Authority of India Ltd), as specified in the Altekar Committee Report of 1994/95 (Planning Commission 1996). Due to a high ash content in the coal supplied to the steel industry (more than 17%), the import dependency for coking coal is steadily increasing.

A major part of non-coking coal in India occurs in thick inter-banded seams. Due to the method of mining currently used in opencast mines, these dirt bands are also mined and dispatched along with coal, thereby increasing the ash content. Due to high ash in non-coking coal received by the power stations, fly ash disposal poses a critical problem. However, the MoEF (Ministry of Environment and Forests), through a Gazette Notification on 19 September 1997, made it mandatory for all power stations located beyond 1000 km from the coalfields and for those located in critically polluted, sensitive and urban areas to use coal with a maximum of 34% ash content with effect from 1 June 2001. Furthermore, under this, a phased introduction of maximum 34% ash in power station feed between 2000 and 2004 was proposed. But the most recent gazette notification GSR 407 (E), dated 31 May 2001, has extended this deadline to 1 June 2002. Currently, about 37% (100 MT) of non-coking coal is transported to power plants located beyond 1000 km from the coalfields. This notification left some consumers with no option but to resort to coal imports, since adequate coal of the requisite quality could not be provided domestically.



Map1 Coalfields and coal consuming industries (December 2001)

Sources
1 Survey of India Dehra Dun
2 Central Electricity Authority New Delhi
3 Coal India Limited Kolkata
4 Cement Manufacturer s Association New Delhi

Facing page no 26

Map 1 Coalfields and coal consuming industries (data)

Cement plants: location and capacity

Sl no.	*Cement plants*	*Location*	*Installed capacity* (million tonnes)
1	CCI Ltd (G)	Tughalakabad, Delhi	0.50
2	CCI Ltd	Charkhi-Dadri, Haryana	0.17
3	ACC Ltd	Gagal, Himachal Pradesh	2.70
4	CCI Ltd	Rajban, Himachal Pradesh	0.20
5	Gujarat Ambuja Ltd	Darlaghat, Himachal Pradesh	1.16
6	J&K Cements	Khrew, J ammu and Kashmir	0.20
7	Gujarat Ambuja Ltd (G)	Ropar, Punjab	1.34
8	ACC Ltd	Lakheri, Rajasthan	0.60
9	Shriram Cement	Kota, Rajasthan	0.20
10	Mangalam Cement	Morak, Rajasthan	0.40
11	Neer Shree Cement	Morak, Rajasthan	0.60
12	Birla Cement	Chittorgarh, Rajasthan	0.60
13	Chittor Cement	Chittorgarh, Rajasthan	0.80
14	J K Cement	Nimbahera, Rajasthan	2.10
15	J K Cement (G)	Mangrol, Rajasthan	0.21
16	J K Udaipur Udyog	Udaipur, Rajasthan	0.90
17	Shree and Raj Cement	Beawar, Rajasthan	2.00
18	Lakshmi Cement	Sirohi Road, Rajasthan	2.23
19	Adityo Cement	Shambhupura, Rajasthan	1.40
20	Ambuja Cement Raj Ltd	Pali, Rajasthan	1.40
21	Binani Cement	Sirohi, Rajasthan	1.65
22	UP State Cement (G)	Chunar, Uttar Pradesh	1.68
23	UP State Cement	Churk, Uttar Pradesh	0.48
24	UP State Cement	Dalla, Uttar Pradesh	0.43
25	Diamond Cement (G)	Jhansi, Uttar Pradesh	0.50
26	ACC Ltd (G)	Tikaria, Uttar Pradesh	0.60
27	Birla Cement (G)	Raebareli, Uttar Pradesh	0.36
28	Kalyanpur Cement	Banjari, Bihar	1.00
29	Sone Valley	Japla, Jharkhand	0.25
30	Lemos Cement	Khalari, Jharkhand	0.11
31	ACC Ltd	Sindri, Jharkhand	0.60
32	ACC Ltd	Chaibasa, Jharkhand	0.61
33	Lafarge	Singhbhum, Jharkhand	1.43
34	OCL India Ltd	Rajgangpur, Orissa	1.00
35	IDCOL Cement	Bargarh, Orissa	0.96
36	L&T Ltd (G)	Jharsuguda, Orissa	0.80
37	Birla Corpn Ltd	Durgapur, West Bengal	0.60
38	Damodhar Cmt & Slag (G)	Purulia, West Bengal	0.53
39	CCI Ltd	Bokajan, Assam	0.20
40	Mawmluh Cherra	Cherrapunji, Meghalaya	0.20
41	ACC Ltd	Madukkarai, Tamil Nadu	0.96
42	Grasim South	Reddipalayam, Tamil Nadu	0.94
43	India Cements	Sankaridurg, Tamil Nadu	0.60
44	Chettinad Cements	Karur, Tamil Nadu	0.60
45	India Cements	Tulaiyuth, Tamil Nadu	1.10
46	India Cements	Trichy, Tamil Nadu	0.90
47	Tamil Nadu Cements	Alangulam, Tamil Nadu	0.40
48	Madras Cements	R S Raja Nagar, Tamil Nadu	0.75

Cement plants continued

Sl no.	*Cement plants*	*Location*	*Installed capacity* , (million tonnes)
49	Dalmia Cements	Dalmiapuram, Tamil Nadu	1.03
50	Tamil Nadu Cements	Ariyalur, Tamil Nadu	0.50
51	Madras Cements	Alathiyur, Tamil Nadu	0.90
52	L&T -TN (G)	Arakonam, Tamil Nadu	1.00
53	ACC Ltd	Macherial, Andhra Pradesh	0.33
54	Orient Cement	Devapur, Andhra Pradesh	1.30
55	Kesoram Cement	Ramagundam, Andhra Pradesh	0.90
56	Andhra Cement (G)	Vijaywada, Andhra Pradesh	0.24
57	Kistna	Kistna, Andhra Pradesh	0.22
58	Zuari Cement	Krishna Nagar, Andhra Pradesh	1.70
59	India Cements	Yerraguntla, Andhra Pradesh	0.40
60	India Cements	Chilamkur, Andhra Pradesh	1.30
61	Madras Cements	Jaggayyapet, Andhra Pradesh	1.10
62	Raasi Cement	Wadapally, Andhra Pradesh	1.80
63	Priyadarshini	Ramapuram, Andhra Pradesh	0.60
64	Sri Vishnu Cement	Sitapuram, Andhra Pradesh	1.00
65	CCI Ltd	Tandur, Andhra Pradesh	1.00
66	Andhra Cement (G)	Vishakhapatnam, Andhra Pradesh	0.50
67	CCI Ltd	Adilabad, Andhra Pradesh	0.40
68	Andhra Cement	Nadikude, Andhra Pradesh	0.50
69	KCP Ltd	Macherla, Andhra Pradesh	0.40
70	Panyam Cements	Bugganipalle, Andhra Pradesh	0.53
71	L&T - AP	Tadipatri, Andhra Pradesh	2.60
72	India Cements - Visaka	Tandur, Andhra Pradesh	0.90
73	HMP Cements Ltd	Shahabad, Karnataka	0.47
74	ACC Ltd	Wadi, Karnataka	2.05
75	Vasavadatta Cement	Sedam, Karnataka	1.20
76	Rajashree Cement	Malkhed, Karnataka	2.00
77	CCI Ltd	Kurkunta, Karnataka	0.20
78	Kanoria Industries	Bagalkot, Karnataka	0.33
79	Mysore Cements	Ammasandra, Karnataka	0.57
80	Malabar Cements	Palaghat, Kerala	0.42
81	L&T Ltd (ACW)	Chandrapur, Maharashtra	3.00
82	Manikgarh Cement	Manikgarh, Maharashtra	1.50
83	ACC Ltd	Chanda, Maharashtra	1.00
84	Narmada Cement	Ratnagiri, Maharashtra	0.40
85	Rajashree Cement (G)	Hotgi, Maharashtra	1.20
86	Indo Rama Cement (G)	Raigad, Maharashtra	1.00
87	Orient Cement	Jalgaon, Maharashtra	0.70
88	Sikka	Sikka, Gujarat	1.08
89	HMP Cements Ltd	Porbandar, Gujarat	0.20
90	Saurashtra Cement	Ranavav, Gujarat	1.16
91	Ambuja Cement	Kodinar, Gujarat	1.00
92	Gujambuja Cement	Kodinar, Gujarat	2.00
93	Gujarat Sidhee Cement	Veraval, Gujarat	1.20
94	Narmada Cement	Jafrabad, Gujarat	0.40
95	Narmada Cement	Magdalla, Gujarat	0.70
96	Tata Chemicals Ltd	Mithapur, Gujarat	0.44

Continue

Cement plants continued

Sl no.	*Cement plants*	*Location*	*Installed capacity* (million tonnes)
97	L&T Ltd	Pipavav, Gujarat	4.20
98	Satna Cement	Satna, Madhya Pradesh	0.75
99	Birla Vikas	Satna, Madhya Pradesh	0.80
100	Jaypee Cement	Rewa, Madhya Pradesh	2.50
101	Jaypee Cement	Bela, Madhya Pradesh	1.50
102	Maihar Cement	Maihar, Madhya Pradesh	2.00
103	ACC Ltd	Kymore, Madhya Pradesh	1.70
104	Diamond Cement	Damoh, Madhya Pradesh	1.03
105	Vikram Cement	Jawad Road, Madhya Pradesh	2.50
106	CCI Ltd	Neemuch, Madhya Pradesh	0.40
107	Prism Cement	Satna, Madhya Pradesh	2.00
108	ACC Ltd	Jamul, Chattisgarh	1.58
109	Century Cement	Tilda, Chattisgarh	1.20
110	Grasim Cement	Raipur, Chattisgarh	1.80
111	CCI Ltd	Akaltara, Chattisgarh	0.40
112	CCI Ltd	Mandhar, Chattisgarh	0.38
113	Raymond Ltd Cem. Div.	Bilaspur, Chattisgarh	2.24
114	L&T Ltd	Hirmi, Chattisgarh	1.90
115	Ambuja Cmt Eastern Ltd	Bhatapara, Chattisgarh	1.80
116	Lafarge	Sonadih, Chattisgarh	0.30

Location of steel plants

Sl no.	*Location*
117	Bokaro, Jharkhand
118	Durgapur, West Bengal
119	Bhilai, Chattisgarh
120	Tisco, Bihar
121	IISCO, West Bengal
122	RINL, Andhra Pradesh
123	Rourkela, Orissa
124	Jindal Vijaynagar Steel Plant, Karnataka

Location of lignite mines

Sl no.	*Location*
125	Panandharo, Kutch, Gujarat
126	Rajpardi, Bharuch, Gujarat
127	Mangrol Vastan, Surat, Gujarat
128	Neyveli, Tamil Nadu
129	Barmer, Rajasthan

Location of coalfields

Sl no.	*Location*
130	Raniganj, West Bengal
131	Jharia, Jharkhand
132	East Bokaro, Jharkhand
133	West Bokaro, Jharkhand
134	Ramgarh, Jharkhand
135	North Karanpura, Jharkhand
136	South Karanpura, Jharkhand
137	Rajmahal, Jharkhand
138	Pench kanhan, Madhya Pradesh
139	Pathakhera, Madhya Pradesh
140	Mohpani, Madhya Pradesh
141	Sohagpur, Madhya Pradesh
142	Singrauli, Madhya Pradesh
143	Chirmiri, Chattisgarh
144	Bisrampur, Chattisgarh
145	Hasdoarand, Chattisgarh
146	Korba, Chattisgarh
147	Mandraigarh, Chattisgarh
148	IB River, Orissa
149	Talcher, Orissa
150	Godavari, Andhra Pradesh
151	Makum, Assam

Location of major coal-handling ports

Sl no.	*Location*
152	Visakhapatnam, Andhra Pradesh
153	Haldia, West Bengal
154	Kolkata, West Bengal
155	Chennai, Tamil Nadu
156	Paradip, Orissa
157	Marmagoa, Karnataka
158	Navlakhi, Gujarat
159	Surat, Gujarat
160	Kandla, Gujarat
161	Okha, Gujarat
162	Mumbai, Maharashtra
163	Sikka, Gujarat
164	Tuticorin, Tamil Nadu
165	New Mangalore, Karnataka
166	Porbandar, Gujarat
167	Cochin, Kerala
168	Dehej, Gujarat
169	Bedi (Jamnagar), Gujarat
170	Kakinada, Andhra Pradesh
171	Veraval, Gujarat

The CIL has decided not to set up any washery of its own, other than on BOO (build-own-operate) or BOOT (build-own-operate-transfer) basis, due to the large costs and gestation period involved. In view of this, the Coal Mines Nationalisation Act, 1973, was amended to include captive washing of coal. Despite having long-term targets for the construction of washing plants with about 60 MT annual capacity for non-coking coal, the construction of washing plants has not kept pace with the increasing demand. Consequently, large quantities of raw coal are being transported to power stations, placing a severe constraint on the country's bulk freight services' capacity in addition to the generation of fly ash.

The blending of imported and domestic coal appears as a possible way to improve the quality of coal. However, infrastructure requirements for blending coal may pose constraints for existing consumers. The CIL is interested to acquire two berths at the newly constructed port at Ennore for the blending of MCL (Mahanadi Coalfields Ltd) the coal with imported coal to meet the demand of power plants in the south for coal with an ash content of less than 34%. The CIL has decided in favour of blending because washing Indian coal is difficult on account of the presence of near-gravity impurities, making it difficult to separate the ash and the coal.

Improvement in quality by selective mining using surface miners has shown great potential in certain mines. This is being used only in some mines and needs large-scale implementation in order to be effective.

Demand estimates and production targets

The Planning Commission had assessed the demand for coal at 412 MT in 2001/02, 545 MT in 2006/07, and 775 MT in 2011/12 (corresponding to the low hydro-generation and high liquid fuel based generation of power) (Ninth Five-year Plan 1997–2002). The corresponding production levels were estimated at 370.6 MT, 499 MT and 672 MT for the respective years. This demand was reassessed as being 370.80 MT (excluding 7.70 MT of middlings) for 2001/02 during the mid-term appraisal of the Ninth Plan. These estimates were further revised downwards by the Planning Commission in the Annual Plan for 2001/02 when demand was estimated to be 354.29 MT in 2001/02.

Table I Annual demand for the Ninth Five-year Plan and actual production (MT)

Year	*Demand*	*Domestic supply*
1997/98	306.41 (5.80)[a]	289.97
1998/99	308.39 (5.01)	291.86
1999/00	324.72 (4.25)	305.02
2000/01	333.18 (4.39)	311.62
2001/02	354.29 (4.83)[b]	324.23

[a] figures in parentheses are for middlings.

[b] assessed by the Planning Commission.

Source MoC (2001)

The actual demand for each year of the Ninth Plan and the corresponding domestic supply is given in Table I.

Compared with domestic availability, the projected demand for coal reveals a demand–supply mismatch of about 30 MT in 2001/02. Unless domestic production is augmented, large quantities of coal will have to be imported, with a huge amount of foreign exchange outflow. This trend is clear in the projections for the Tenth Plan period (2002–07) made by the Working Group on Coal and Lignite, which estimates a demand–supply gap of 111 MT for the terminal year of the Tenth Plan (Table II).

Of the projected gap of 111 MT, coal imports are estimated to meet 63 MT of demand, with the remaining 48 MT to be met by increasing domestic coal production (MoC 2001). This implies that domestic production will have to be increased by 125 MT in the next five years in order to cover the gap. This entails huge investment requirements, with an estimated 193 billion rupees

Table II Demand–supply scenario for the coal sector: Tenth Plan period (2002-07) (million tonnes)

Year	*Demand*	*Domestic supply*	*Gap*
2002/03	373.32	320.44	52.88
2003/04	402.84	335.54	67.30
2004/05	454.91	350.87	104.04
2005/06	488.05	366.57	121.48
2006/07	510.83	399.73	111.10

Source MoC (2001)

needed to increase domestic coal production to 400 MT in 2006/07 (MoC 2001).

Mining technology

Over the last decade, India has witnessed a rapid shift in mining technology in favour of opencast mining. The overall increase in coal production can also be attributed to the increased share of opencast mining in the country. At the end of the Ninth Plan period, production from opencast mining comprised 81% of total production. By 2006/07, the terminal year of the Tenth Plan, the share is expected to increase slightly to 82% (MoC 2001).

Despite substantial investment, the productivity of underground mines has not improved much due to difficult mining conditions, low levels of skill, and a large workforce. This trend is fast depleting the reserves amenable to opencast mining. Immediate action, therefore, needs to be initiated to develop underground mines, which have great potential for meeting future demands in view of their long gestation periods. An increase in the level of opencast mining has caused deterioration in the quality of coal supplied.

To counter this, surface miners have been successfully introduced in some mines of the Ib Valley coalfields. Surface miners peel slices of coal in 15–23 cm thick layers, which facilitates the segregation of shale bands. Selective mining can also be practised to achieve similar results with the conventional shovel-dumper combination.

Productivity or overall OMS (output per manshift) has improved during the last decade for the CIL and the SCCL (Singareni Collieries Company Ltd) group of companies. The overall productivity is 2.23 tonnes for the CIL and 1.39 tonnes for the SCCL. Although the OMS for opencast mining has improved, the OMS for underground mining has either declined or stagnated (Table 1.14). In 1994, the US had an average of 37.5 tonnes per person-shift, and the figure in Germany's Hambach lignite mine was 43 tonnes per person-shift. So, there is much scope for improvement in the productivity of Indian mines.

Movement of coal

Since most of the coal production in the country is restricted to the eastern and south-eastern belts of the country and core consumers such as power, cement, and steel plants are often distant from the coalfields, transportation of coal to consumers is a major consideration. The railways are the main mode of transportation (accounting for about 57% of the total coal movement in the country) followed by captive systems such as merry-go-rounds. Road transport, conveyors, and aerial ropeways are also used in some areas. About six per cent of India's domestic coal transport is sea-borne. Coastal shipment is used for supplying coal to consumers in South India.

The freight of coal on the Indian railways has always been very high because it cross-subsidises the freight of certain essential commodities such as food grains, fertilizers, and passenger fare.

India has 11 major ports, managed by the Port Trust of India under the jurisdiction of the central government. Important ports on the eastern coast, namely Haldia, Paradip, and Visakhapatnam, as well as several minor and intermediate ports, mostly on the west coast, receive coal imports. Around 11 MT of coal is carried by rail over relatively short distances to these ports each year, to be shipped to the southern ports of Chennai and Tuticorin for consumption by the nearby power utilities. Coal imports are also received at these ports. The government recently allowed private sector participation in the development and augmentation of port facilities.

Coal imports

Coal can be freely imported by consumers based on requirements and commercial judgements under the OGL (open general licence). Coking coal is imported by SAIL and other steel manufacturers to bridge the gap between requirements and indigenous availability and also to improve the quality of the overall blend. With the lowering of import duty and the increase in price of domestic coal consequent to the deregulation of indigenous coal prices, a number of coal-based power plants and cement plants have also started importing non-coking coal in consideration of transportation logistics and against export entitlements. Non-coking coal imports rose from 4.70 MT in 1997/98 to 9.31[2] MT in 2000/01. Imports of coking and non-coking coal are shown in Table 1.12.

---

[2] Provisional data from the Coal Controller Organization, Ministry of Coal

At a basic customs duty of 15%, imports of coal were favourable, especially near the ports. Consequently, imports of non-coking coal increased since the decontrol of prices, which was followed by repeated price increase of domestic coal. To protect the domestic coal market, the basic import duty was increased to 25% in May 2000. This was expected to make imports less remunerative and give an edge to Indian coal producers over the overseas producers. Although cement plants located inland and the sponge iron plants (direct reduction process using higher-grade non-coking coal) felt the impact of this increase, imports have been increasing.

In June 2000, the government enhanced the basic customs duty on Chinese coke to 15% from the earlier 5% following the dumping of coke by the Chinese. Recently, the government reduced this duty to five per cent again. This will help the mini blast-furnace operators at the cost of domestic coke merchants.

Reforms in the coal sector

Given the importance attached to coal and lignite resources in India's overall energy strategy and the urgent need to develop these resources, the Planning Commission constituted a Committee on Integrated Coal Policy, which submitted its report in May 1996. The major recommendations included adoption of coal conservation measures; augmentation of domestic coal production by involving the private sector, integrating the exploratory efforts for coal and lignite, deregulation of coal prices, creating a regulatory body to look into price disputes, etc.; setting up more pithead coal/lignite-based thermal power stations; augmenting railways and port infrastructure facilities; and amending/modifying various acts to facilitate private sector participation and expedite project clearance procedures. Deregulation of the prices and distribution of all grades of coal and coal products are the only recommendations implemented so far by the government. Other recommendations are reported to be under consideration of the government.

In April 1999, TERI was commissioned by the Ministry of Coal to conduct a review of the regulatory framework in the coal industry and to suggest improvements based on best practices abroad. The report was submitted to the ministry in March 2000, recommending, among other things, the revamping of many acts that impinge on the coal industry, removing the restrictions on private mining, redefining the role of the Ministry of Coal, the CIL, Coal Controller Organization, CMPDIL (Central Mine Planning and Design Institute Limited) etc.

The recent move by the government towards reforming the coal sector has been the constitution of the ERC (Expenditure Reforms Commission), which submitted its report in September 2000. Part IV of the report relates to 'restructuring of functions, activities and structures in the Ministry of Coal'. The major recommendations of the commission are given below.

- Remove all restrictions on the entry of the private sector in exploration and production of coal by amending the Coal Mines Nationalisation Act, 1973.
- Amend the Coal Bearing Areas (Acquisition and Development) Act, 1957, and set up an independent regulatory body to allow a level playing field to the private sector.
- Restructure the industry by doing away with the holding company (CIL) and Coal Controller, closing down the loss-making Dankuni LTC (low temperature carbonization) plant / regional offices, and convert the CMPDIL into an independent technical advisory body.
- Amend the Coal Mines (Conservation and Development) Act, 1974, to put responsibility on both public and private sectors for scientific mining, conservation, safety and health, protection of environment, etc.
- Permit states to develop lignite resources outside the command area of Neyveli Lignite Corporation.
- Reorient the overall strategy to take into consideration the role of coal in energy security.

Captive coal mining

After the nationalization of coal mines in 1972/73, the development of coal was confined to the public sector. But in the early 1990s, the Government decided to permit private sector participation in the power sector to augment thermal power generation and to create additional power generating capacity. The Coal Mines (Nationalization) Act, 1973, was amended on 9 June 1993 to allow captive coal mining for captive consumption of power generation to meet the anticipated increased demand from private power producers. Later, production of cement and washing of coal for captive use was added to the list.

Several parties in the public and private sector have been offered captive coal blocks for consumption in power generation, the iron and steel industry, and the cement industry, but the result has not been encouraging. The reason given was that the quality of blocks offered for captive mining was generally of poor quality and, therefore, failed to attract private investors.

In April 2000, a bill proposing further amendment to the Coal Mines (Nationalization) Act of 1973 was prepared to open up coal mining to private companies. If passed, private companies will be able to undertake the non-captive mining of coal. The new law will provide free mining for all, with certain pre-conditions for the location and minimum size of the mines so that coordinated and scientific development may take place.

Pricing reforms

On 1 April 2000, the pricing of coal became fully deregulated *vide* the Colliery Control Order, 2000. This order supersedes the Colliery Control Order, 1945, of the Essential Commodities Act, 1955, under which the central government was empowered to fix the prices of coal by grade and colliery. The prices of all grades of coal have been increased several times after the decontrol (Table 1.28).

Legislative framework

Coal exploration and mining in India is governed by a large number of acts, rules, and regulations. Opening new mines and subsequent operations require statutory permission from the Department of Coal, the Director-General of Mine Safety, the MoEF, the State Pollution Control Board, and the respective state governments. Coal mining projects in India are required to address environmental and social issues. The Environment Action Plan, the Rehabilitation Action Plan, and the Indigenous People's Development Plan are now an integral part of any coal project.

The legal and regulatory frameworks need to reflect the policy of the government. The revision of the legislative framework, however, has not kept pace with the evolving policy that aims to reduce the role of the government as a developer of resources. The legislative provisions, therefore, need to operate within a framework that is beneficial to the investors and provides access to the latest technologies in the coal industry.

Policy recommendations

In a liberalized economy, competition is the guiding factor for reliable delivery of products and services. Currently, the bulk of coal production is from national coal companies and thus there is effectively no competition in the industry.

Private sector participation needs to be facilitated so as to bring about competition amongst the coal producers and to prevent cartelization. Necessary legislative changes have to be made to facilitate private sector participation in coal production and distribution. Although some changes have been initiated, administrative procedures must be further streamlined to expedite the necessary clearances and the required legislative changes.

Delays in new projects because of a paucity of funds can be reduced by forming joint ventures between the public and private sector coal companies and the concerned state government. This will not only help resolve procedural difficulties in project implementation but also overcome problems related to land acquisition, rehabilitation of people ousted from the land, and forest clearances.

Joint ventures will lead to consumer satisfaction with regard to quality and regularity in the supply of coal. Some of the independent power producers, for instance, may have the resource but lack the expertise to take up mining, in which case they may wish to enter into an equity participation arrangement with existing coal companies. Similarly, public sector utilities, such as the National Thermal Power Corporation may like to tie up with the CIL for their proposed pithead power stations. In addition, SAIL and other steel producers in the private sector may enter into joint ventures with the CIL for developing new coking coal mines instead of relying on imports for their future requirements.

Due to the pre-liberalization structure of the coal industry, characterized by a high concentration of reserves and assets in the hands of nationalized producers, the infrastructure bottlenecks, and the statutory and legal barriers, the Indian coal sector may not operate under conditions of competitive price-setting over the medium term. Moreover, transition from a monopoly to a competitive system requires balancing the interests of various stakeholders in the market. This clearly implies the indispensability of a regulatory body.

Conclusions

India's coal demand is expected to increase manifold within the next 5–10 years in view of the completion of ongoing coal-based power projects, and of demand from metallurgical and other industries. The demand for coal has been rising at an annual rate of six per cent since 1992/93, and the CIL and its subsidiaries will be unable to meet the demand by themselves.

Today, coal as an energy source in India is threatened by alternative fuels whose easy availability and price competitiveness was brought about by recent reforms. Competition in the coal sector will ensure the production and distribution of good quality coal at reasonable prices.

For a meaningful change, the entire energy scenario of the country should be considered from a wider perspective, and sectoral policies carefully examined within the overall context of the national energy policy, taking into consideration all energy sectors.

The Indian coal industry must regard itself against an international horizon and not merely focus on the import of technology. Difficult mining conditions demand that we develop indigenous technologies to attain sustainability. Finally, raising the level of productivity in Indian mines is essential to enable competitiveness in a dynamic world market.

References

MoC (Ministry of Coal). 2000
Annual Report 2000/01
New Delhi: MoC, Government of India

MoC (Ministry of Coal). 2001
Report of the Working Group on Coal and Lignite for the Tenth Five Year Plan (2002–07)
New Delhi: MoC, Government of India

Planning Commission. 1996
Report of the Working Group on Coal and Lignite for the Formulation of the Ninth Five-Year Plan
New Delhi: Planning Commission, Government of India.

Ninth Five-year Plan 1997–2002. Volume II
New Delhi: Planning Commission, Government of India

Table 1.01 Coal resources of states (**million tonnes**): 1 January 2001

State	*Proved*	*Indicated*	*Inferred*	*Total*
Andhra Pradesh	7 529.4	3363.8	2 781.7	13 674.9
Arunachal Pradesh	31.2	11.0	48.0	90.2
Assam	259.4	26.8	34.0	320.2
Bihar	35 147.6	28 444.2	5 582.8	69 174.6
Madhya Pradesh	14 017.3	22 102.1	8 199.7	44 319.0
Maharashtra	4 388.5	1 301.7	1 605.4	7 295.6
Meghalaya	117.8	40.9	300.7	459.4
Nagaland	3.4	1.4	15.2	19.9
Orissa	11 307.7	23 728.5	16 535.1	51 571.3
Uttar Pradesh	766.0	295.8	0	1 061.8
West Bengal	10 845.6	10 925.7	4 147.3	25 918.5
Total	84 413.9	90 241.8	39 249.8	213 905.5

Source
MoC. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Coal.

For more details, please see TEDDY ONLINE+ [Section: Coal (reserves)]

Table 1.02 Coal reserves by category (**million tonnes**): 1 January 2001

Types of coal	*Proved*	*Indicated*	*Inferred*	*Total*
Coking				
Prime coking	4 614.4	698.7	–	5 313.1
Medium coking	11 293.7	11 225.7	1 106.4	23 625.8
Blendable/semi-coking	482.2	904.0	221.7	1 607.9
Sub-total	16 390.2	12 828.5	1 328.1	30 546.7
Non-coking[a]	68 023.7	77 413.4	37 921.7	183 358.8
Total	84 413.9	90 241.8	39 249.8	213 905.5

[a] including coals of the north-eastern region

Source
MoC. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Coal.

For more details, please see TEDDY ONLINE+ [Section: Coal (reserves)]

Table 1.03 Lignite reserves of states and union territories (**million tonnes**): 1999/2000

State / Union Territory	*Geological reserves*
Tamil Nadu and Pondicherry	
Neyveli	3300
Bahur	575
Jayamkondacholapuram	1150
Mannargudi	22883
East of Veeranam	1422
Kudikadu	133
Micheal Patti	23
Meensuruti	458
Kulanchavadi	175
Gujarat	1527
Jammu and Kashmir	128
Kerala	108
Rajasthan	2286
Total	34 168

Source
MoC. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Coal.

For more details, please see TEDDY ONLINE+ [Section: Coal (reserves)]

Table 1.04 All-India production of coal, lignite, and other derivatives (million tonnes): 1975/76 to 1999/2000

Item	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Coking coal	27.4	31.7	35.2	44.9	45.80	45.21	44.66	41.97	39.91	40.50	43.80	39.2	33.3
Non-coking coal	72.3	82.3	119.1	169.0	187.00	196.80	204.02	215.80	233.50	245.50	253.33	257.3	270.8
Total coal[a]	99.7	114.0	154.3	213.9	232.80	242.00	248.68	257.77	273.42	286.10	297.20	296.5	304.1
Lignite	3.0	5.1	8.0	14.1	15.99	16.62	18.10	19.31	22.15	22.60	23.10	23.4	22.1
Total coal and lignite	102.7	119.1	162.3	225.7	245.40	255.11	266.78	277.08	295.56	308.70	320.20	315.7	326.2
Soft coke	2.7	2.3	1.7	0.9	0.73	0.48	0.43	0.25	0.17	0.10	–	–	–
Beehive hard coke	0.8	0.6	0.3	0.1	0.17	0.13	0.12	0.08	0.06	0.10	0.10	–	–
By-product hard coke	0.6	0.4	0.3	10.2	10.48	10.60	10.58	10.93	10.86	11.00	10.60	10.8	11.4
Washed coal	11.4	11.6	10.9	11.2	12.50	12.80	12.14	11.75	11.92	10.90	10.00	9.7	9.1
Middlings	3.9	4.3	5.1	5.6	6.07	6.46	6.64	6.30	6.80	6.80	7.60	7.2	6.2
Total exports	0.4	0.1	0.2	0.1	0.11	0.13	0.10	0.12	0.09	0.10	0.10	–	–
Total imports	–	0.6	2.0	4.9	5.92	6.70	7.10	8.30	8.90	9.50	9.50	–	–

[a] includes Meghalaya figures for the unorganized sector

Source

CCO. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

For more details, please see TEDDY ONLINE+ Section: [Coal (general, production, and despatch)]

Table 1.05 Coal production of various states (**million tonnes**): 1975/76 to 2000/2001

State	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*[c]
Andhra Pradesh	7.4	10.1	15.7	17.7	20.6	22.5	25.3	25.7	26.8	28.7	28.9	27.3	29.6	30.3
Assam	0.6	0.6	0.9	0.7	1.0	1.1	1.2[a]	1.2[a]	0.8	0.8	0.7	0.6	0.6	0.7
Bihar	41.8	46.6	54.3	67.3	69.0	71.1	73.3	73.3	74.6	77.7	81.3	76.2	76.9	75.4
Madhya Pradesh	20.4	25.9	42.6	65.2	69.4	70.7	72.9	74.9	79.8	83.3	84.8	84.9	87.9	92.7
Maharashtra	3.7	5.8	11.6	16.9	18.9	19.7	20.5	21.1	22.8	24.9	26.2	25.3	27.7	28.8
Meghalaya	–	–	–	2.2	3.5	3.5	2.5	3.3	3.3[b]	3.2	3.2	4.2	4.1	–
Orissa	2.2	3.2	6.0	16.2	20.7	23.1	24.3	27.3	32.7	37.4	42.2	43.5	43.6	44.8
Uttar Pradesh	–	1.8	3.9	10.5	11.5	12.2	12.1	13.8	14.8	15.4	15.8	15.6	16.2	16.9
West Bengal	23.7	20.0	19.4	17.2	18.2	18.1	16.6	17.2	17.9	18.0	17.4	18.8	17.6	20.1
All-India	99.8	114.0	154.4	213.9	232.8	242.0	248.7	257.8	273.5	289.3	300.4	296.5	304.0	309.6

[a] includes Arunachal Pradesh and Meghalaya under the north-eastern coalfields

[b] figures for the unorganized sector

[c] provisional data from Coal Controller's Organization

Source

CCO. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

For more details, please see TEDDY ONLINE + [Section: Coal (general, production, and despatch)]

Table 1.06 Coal despatches of various states (**million tonnes**): 1975/76 to 2000/2001

State	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*[c]
Andhra Pradesh	7.0	10.1	15.4	24.6	20.0	21.7	24.6	24.0	24.9	28.8	29.0	26.7	29.7	30.3
Assam	0.6	0.1	0.8	0.9	1.0	0.9	0.8[a]	0.8[a]	1.0[a]	0.8	0.6	0.7	0.8	0.8
Bihar	33.1	39.1	53.7	60.8	63.1	69.4	72.6	73.2	72.7	76.0	77.1	75.5	77.3	76.5
Madhya Pradesh	19.5	24.6	42.0	62.8	68.0	69.7	72.1	73.1	78.6	83.7	86.5	83.8	87.0	91.1
Maharashtra	3.4	5.7	11.7	17.4	18.9	19.1	19.8	21.2	24.3	24.7	25.0	24.3	28.4	28.4
Meghalaya	–	–	–	2.2	3.5	3.5	2.5	3.3	3.3[b]	3.2	3.2	4.2	4.1	–
Orissa	2.0	2.8	5.3	16.0	19.6	21.9	24.0	26.9	34.4	37.2	43.3	41.8	42.1	47.3
Uttar Pradesh	–	1.6	3.6	10.2	11.4	11.6	12.9	13.7	14.9	15.7	15.6	14.7	16.8	19.0
West Bengal	21.2	17.3	18.5	15.7	17.1	16.3	15.8	16.2	16.6	16.7	16.8	17.2	18.7	19.2
All-India	86.8	101.3	151.0	210.6	222.6	234.1	245.1	252.4	270.7	286.8	297.1	288.9	304.9	313.0

[a] includes Arunachal Pradesh and Meghalaya under the north-eastern coalfields

[b] figures for the unorganized sector

[c] provisional data from Coal Controller's Organization

Source

CCO. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

For more details, please see TEDDY ONLINE + [Section: Coal (general, production, and despatch)]

Table 1.07 Coal pithead stock of various states (million tonnes): 1975/76 to 2000/01

State	1975/76	1980/81	1985/86	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01[a]
Andhra Pradesh	0.5	0.5	0.6	0.7	0.7	0.9	0.9	2.1	2.5	1.9	1.4	1.7	1.2	0.9
Assam	–	–	0.2	0.3	0.1	0.4	0.8	1.2	0.9	0.8	0.9	0.8	0.6	0.5
Bihar	6.8	11.1	16.5	24.7	29.4	29.2	28.5	22.4	22.9	20.8	23.4	18.1	15.3	5.9
Madhya Pradesh	1.7	3.3	6.1	7.8	8.4	8.7	8.9	10.0	10.6	9.5	7.1	7.8	8.2	7.6
Maharashtra	0.2	0.2	0.8	2.4	2.1	2.6	3.0	2.7	1.0	1.1	2.0	2.8	2.1	2.0
Meghalaya	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Orissa	0.4	0.5	2.1	3.1	4.1	4.6	4.8	5.2	3.4	3.5	2.3	4.0	5.4	2.9
Uttar Pradesh	0	0.1	0.2	0.7	0.8	1.5	0.6	0.8	0.7	0.4	0.4	1.3	0.5	0.1
West Bengal	2.2	2.7	2.5	2.9	2.9	3.5	3.1	3.2	3.7	4.1	3.9	3.7	2.3	0.7
All-India	11.8	18.4	29.0	42.6	48.5	51.4	50.6	47.6	45.7	42.0	41.5	40.1	35.6	21.5

[a] provisional data from Coal Controller's Organization

Source

CCO. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

For more details, please see TEDDY ONLINE + [Section: Coal (general, production, and despatch)]

Table 1.08 Coal production of various companies (**million tonnes**): 1993/94 to 2000/01

Company	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*[a]
Coal India Ltd								
Eastern Coalfields Ltd	22.61	24.85	27.80	29.65	27.44	27.16	25.12	28.02
Bharat Coking Coal Ltd	29.04	28.75	27.81	27.14	30.92	27.18	27.90	26.02
Central Coalfields Ltd	33.51	31.21	30.76	32.21	33.10	32.18	32.40	31.76
South-Eastern Coalfields Ltd	47.53	50.00	53.17	55.30	56.63	57.56	58.75	60.33
Mahanadi Coalfields Ltd	24.29	27.33	32.70	37.37	42.16	43.51	43.55	44.80
Western Coalfields Ltd	26.50	27.24	29.01	31.23	32.51	31.74	33.86	35.20
Northern Coalfields Ltd	31.41	32.50	35.20	37.01	37.56	36.52	38.43	41.40
North-Eastern Coalfields	1.20	1.19	0.82	0.75	0.69	0.64	0.57	0.66
Total	216.10	223.07	237.28	250.65	261.01	256.49	260.59	268.19
Singareni Collieries Company Ltd	25.28	25.65	26.77	28.73	28.94	27.33	29.56	30.27
Jammu and Kashmir Minerals Ltd	0.02	0.02	0.02	0.02	0.01	0.01	0.03	0.03
Damodar Valley Corporation	0.07	0.29	0.23	0.29	0.36	0.37	0.79	0.37
Bengal Emta Coal Mines Ltd	–	–	–	–	0.71	1.80	2.17	2.41
Bihar State Mineral Development Corporation Ltd	–	–	–	0.26	0.20	0.19	0.29	0.40
Indian Iron and Steel Company Ltd	0.72	1.04	0.99	0.86	0.72	0.84	1.03	1.24
Tata Iron and Steel Company Ltd	3.96	4.16	4.90	5.30	5.23	5.22	5.16	5.28

[a] provisional data from Coal Controller's Organization

Source

CCO. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

Table 1.09 Coal despatches of various companies (**million tonnes**): 1993/94 to 2000/01

Company	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*[a]
Coal India Ltd								
Eastern Coalfields Ltd	22.19	24.22	25.81	28.04	26.64	25.54	25.89	27.73
Bharat Coking Coal Ltd	28.54	28.34	26.55	26.75	27.57	26.83	28.59	25.64
Central Coalfields Ltd	33.02	31.18	30.84	31.19	32.49	31.98	32.55	32.60
South-Eastern Coalfields Ltd	46.91	47.81	52.27	56.12	58.33	56.93	57.57	60.43
Mahanadi Coalfields Ltd	24.00	26.93	34.36	37.22	43.40	41.76	42.08	47.30
Western Coalfields Ltd	25.52	27.26	30.37	30.91	31.35	30.44	34.63	35.21
Northern Coalfields Ltd	32.37	32.92	35.07	37.09	37.47	35.46	39.18	41.88
North-Eastern Coalfields	0.75	0.83	1.03	0.83	0.57	0.70	0.82	0.76
Total	213.30	219.49	236.29	248.15	257.82	249.63	261.32	271.54
Singareni Collieries Company Ltd	24.60	25.04	24.87	28.82	29.02	26.71	29.74	30.31
Jammu and Kashmir Minerals Ltd	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.03
Damodar Valley Corporation	0.07	0.27	0.23	0.29	0.36	0.33	0.35	0.38
Bengal Emta Coal Mines Ltd	–	–	–	–	0.69	1.78	2.18	2.41
Bihar State Mineral Development Corporation Ltd	–	–	–	0.26	0.19	0.20	0.28	0.40
Indian Iron and Steel Company Ltd	0.68	1.03	1.00	0.87	0.73	0.81	1.01	1.26
Tata Iron and Steel Company Ltd	3.94	4.28	4.91	5.29	5.20	5.21	5.13	5.28

[a] provisional data from Coal Controller's Organization

Source

CCO. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

Table 1.10 Coal pithead stock of various companies (**million tonnes**): 1993/94 to 2000/01

Company	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*[a]
Coal India Ltd								
Eastern Coalfields Ltd	6.55	6.17	7.21	5.19	5.09	5.90	4.48	2.44
Bharat Coking Coal Ltd	13.29	8.02	8.56	8.26	10.95	4.76	2.54	2.13
Central Coalfields Ltd	11.51	11.13	10.57	11.21	11.03	10.91	10.37	2.85
South-Eastern Coalfields Ltd	7.07	8.80	9.22	7.89	6.01	6.27	7.09	6.67
Mahanadi Coalfields Ltd	4.82	5.15	3.40	3.48	2.29	4.00	5.41	2.90
Western Coalfields Ltd	3.52	3.15	1.44	1.43	2.29	3.31	2.32	2.19
Northern Coalfields Ltd	1.91	1.49	1.61	1.62	1.27	2.29	1.43	0.77
North-Eastern Coalfields	0.82	1.17	0.87	0.83	0.93	0.84	0.57	0.46
Total	49.48	45.07	42.87	39.9	39.84	38.28	34.18	20.41
Singareni Collieries Company Ltd	0.95	2.09	2.52	1.89	1.38	1.67	1.21	0.95
Jammu and Kashmir Minerals Ltd	0.01	0.01	–	–	–	–	0.01	0.01
Damodar Valley Corporation	–	0.02	–	–	–	0.04	0.06	0.05
Bengal Emta Coal Mines Ltd	–	–	–	–	0.02	0.03	0.02	–
Bihar State Mineral Development Corporation Ltd	–	–	–	0.01	0.01	0.03	0.02	0.02
Indian Iron and Steel Company Ltd	0.27	0.23	0.21	0.18	0.17	0.01	0.02	0.03
Tata Iron and Steel Company Ltd	0.05	0.08	0.05	0.04	0.04	0.04	0	–

[a] provisional data from Coal Controller's Organization

Source
CCO. *Coal Directory of India* (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

Table 1.11 Production (**million tonnes**) of coking coal and non-coking coal by companies and fields: 1994/95 to 1999/2000

State / Field / Company	*1994/95*		*1995/96*		*1996/97*		*1997/98*		*1998/99*		*1999/2000*	
	Coking	*Non-coking*	*Coking*	*Non-coking*	*Coking*	*Non-coking*	*Coking*	*Non-coking*	*Coking*	*Non-coking*	*Coking*	*Non-coking*
West Bengal												
Bharat Coking Coal Ltd	0.18	0.57	0.17	0.51	0.13	0.43	0.13	0.59	0.13	0.42	0.31	0.32
Eastern Coalfields Ltd	0.14	15.82	0.13	16.68	0.15	16.95	0.09	15.73	0.08	16.05	0.06	14.59
Indian Iron and Steel Company Ltd	0.02	0.51	0.01	0.42	0.03	0.30	0.05	0.16	0.01	0.29	0.02	0.52
Bengal Emta Coal Mines Ltd	–	–	–	–	–	–	–	0.71	–	1.79	–	2.17
Total	0.34	16.90	0.31	17.61	0.31	17.69	0.27	17.18	0.22	18.55	0.39	17.59
Bihar												
Bharat Coking Coal Ltd	22.30	5.69	21.55	5.58	21.27	5.31	24.19	6.01	21.57	5.06	16.58	10.69
Eastern Coalfields Ltd	0.29	8.60	0.24	10.76	0.22	12.33	0.21	11.42	0.21	10.83	0.17	10.30
Central Coalfields Ltd	13.38	18.11	11.45	19.31	11.75	20.43	12.23	20.87	10.03	22.15	8.98	23.40
Damodar Valley Corporation	–	0.29	–	0.23	–	0.29	–	0.36	0.37	–	0.37	–
Bihar State Mineral Development Corporation Ltd	–	–	–	–	–	0.26	–	0.20	–	0.19	–	0.29
Indian Iron and Steel Company Ltd	0.51	–	0.56	–	0.52	–	0.51	–	0.53	0.01	0.50	–
Tata Iron and Steel Company Ltd	4.16	–	4.90	–	5.30	–	5.23	–	5.14	0.08	5.16	–
Total	40.64	32.69	38.69	35.87	39.05	38.63	42.36	38.85	37.84	38.32	31.75	44.70
Outlying fields												
Northern Coalfields Ltd	–	32.50	–	35.20	–	37.01	–	37.56	–	36.52	–	38.43
South-Eastern Coalfields Ltd	0.13	49.87	0.16	53.01	0.48	54.83	0.47	56.16	0.46	57.10	0.48	58.27
Mahanadi Coalfields Ltd	–	27.33	–	32.70	–	37.37	–	42.16	–	43.51	–	43.55
Western Coalfields Ltd	0.86	26.39	0.75	28.25	0.70	30.52	0.74	31.78	0.65	31.08	0.63	33.22
North-Eastern Coalfields	–	1.19	–	0.82	–	0.75	–	0.69	–	0.64	–	0.57
Singareni Collieries Company Ltd	–	25.65	–	26.77	–	28.73	–	28.94	–	27.33	–	29.56
Jammu and Kashmir Minerals Ltd	–	0.02	–	0.02	–	0.02	–	0.01	–	0.01	–	0.03
Total	0.99	162.95	0.91	176.78	1.18	189.23	1.21	197.30	1.11	196.19	–	–

Public												
Coal India Ltd	37.28	186.07	34.45	202.82	34.69	215.93	38.06	252.62	34.04	251.19	–	–
Singareni Collieries Company Ltd	–	25.65	–	26.77	–	28.73	–	28.94	–	27.33	–	29.56
Jammu and Kashmir Minerals Ltd	–	0.02	–	0.02	–	0.02	–	0.01	0.01	0.01	–	0.03
Damodar Valley Corporation	–	0.29	–	0.23	–	0.29	–	0.36	0.37	–	0.37	–
Bengal Emta Coal Mines Ltd	–	–	–	–	–	–	–	0.71	–	1.79	–	2.17
Bihar State Mineral Development Corporation Ltd	–	–	–	–	–	0.26	–	0.20	–	0.19	–	0.29
Indian Iron and Steel Company Ltd	0.53	0.51	0.57	0.42	0.55	0.30	0.56	0.16	0.53	0.01	0.50	–
Total	37.81	212.54	35.02	230.25	35.25	245.54	38.62	252.62	34.04	251.19	–	–
Private												
Tata Iron and Steel Company Ltd	4.16	–	4.90	–	5.30	–	5.23	0.71	5.14	6.14	5.16	7.01
All India	41.97	212.54	39.91	230.25	40.54	245.54	43.84	253.33	39.18	257.33	33.25	270.78

Source

CCO. 2000. ***Coal Directory of India 1999/2000***. Kolkata: Coal Controller's Organization, Ministry of Coal.

Table 1.12 Import of coking and non-coking coal (million tonnes): 1991/92 to 2000/01

Year	*Coking coal*	*Non-coking coal*	*Total*
1991/92	5.27	0.66	5.93
1992/93	6.32	0.42	6.74
1993/94	6.82	0.57	7.39
1994/95	10.15	1.24	11.39
1995/96	9.37	3.14	12.51
1996/97	10.62	2.56	13.18
1997/98	11.74	4.70	16.44
1998/99	10.02	6.51	16.53
1999/2000	10.99	8.71	19.70
2000/01[a]	12.25	9.31	21.56

[a] provisional data from Coal Controller's Organization

Source
MoC. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Coal.

Table 1.13 Allotted captive mining blocks: March 1997

Thermal power station / Company	*Captive block*	*Estimated coal reserves* (million tonnes)	*Estimated production potential* (million tonnes a year)
Power sector			
RPG/CESC - Budge Budge	Sarisathali	60 (mineable)	3.0
RPG - Chandil	South Dhadhu	60 (mineable)	2.0
RPG - Dholpur	Mahan	75 (mineable)	2.5
KPC - Duburi	Utkal-A	200 (geological)	2.5
NDIL - Bhadravati	Lohara W Baranj (IIV) and Bander	286 (geological)	4.5
APSEB - Krishnapatnam I	Gopalprasad	240 (mineable)	10.8
APSEB - Visakhapatnam II	West II		
TNEB	Gopalprasad W I	240 (mineable)	8.0
INDALCO - Hirakud	Talabira I	17 (geological)	0.5
DCL - Sagardighi	Chuperbhita	289 (geological)	5.0
ACC - Wadi	Lohara East	14 (mineable)	0.3
HOKI - Hospet	Utkal B 1 (since withdrawn)	200 (geological)	2.0
WBSEB - Bandel and Santaldih	Tara East	40 (mineable)	1.2
Videocon - N. Chennai II	Utkal B 1	200 (geological)	5.0
Jindal Strips - Raigarh	Gare Pelma	100 (geological)	1.0
Iron and steel			
Jindal Strips Ltd	Gare block sub-block IV/I	–	–
Prakash Industries	Hasdev Avand	–	–
Birla Technical Service Ltd	Pakribarwadih	–	–
Steel Authority of India Ltd	Seetanala, Tasra, Parbatpur and Mahal	–	–
Monnet Ispat Ltd	Gare block sub-block IV/5	–	–
Cement			
ACC Ltd	Bisrar	–	–
J K Corporation Ltd	Gare-Palma IV/8	–	–

RPG – Reliance Power Group; CESC – Calcutta Electric Supply Company; KPC – Karnataka Power Corporation; NDIL – Nippon Denro Ltd; APSEB – Andhra Pradesh State Electricity Board; TNEB – Tamil Nadu Electricity Board; INDALCO – Indian Aluminium Company Ltd; DCL – Development Consultant Ltd; ACC – Associated Cement Company Ltd; WBSEB – West Bengal State Electricity Board

Source
Data obtained from the Ministry of Coal, New Delhi (1998).

Table 1.14 OMS (Output per man-shift) in opencast and underground mining (**tonnes**): 1975/76 to 2000/01

Company	*1975/76*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*[a]	*1999/2000*	*2000/01*
Overall													
CIL	0.65	0.92	1.30	1.40	1.46	1.52	1.63	1.75	1.86	1.93	2.03	2.11	2.23
SCCL	0.69	0.92	0.96	0.98	1.04	1.05	1.08	1.23	1.19	1.31	1.31	1.42	1.39
Opencast													
CIL	0.90	2.24	3.31	3.70	3.80	4.00	4.35	4.73	5.12	5.07	5.52	5.46	5.95
SCCL	0	3.54	4.74	4.48	4.46	4.38	3.63	3.66	2.96	3.50	3.92	4.43	5.49
Underground													
CIL	0.60	0.53	0.53	0.53	0.55	0.55	0.56	0.56	0.57	0.57	0.59	0.61	0.63
SCCL	–	0.87	0.65	0.67	0.70	0.71	0.69	0.74	0.72	0.76	0.75	0.75	0.77

CIL - Coal India Ltd; SCCL - Singareni Collieries Company Ltd

[a] April-December

Note

The OMS of the SCCL is worked out on the CIL formula from 1987/88.

Source

MoC. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Coal.

For more details, please see TEDDY ONLINE+ Section: [Coal (general, production, and despatch)]

Table 1.15 Categorization of coal and coke

Class	*Grade*	*Properties*
Non-coking coal produced in all states other than Assam, Arunachal Pradesh, Meghalaya, and Nagaland	A	UHV (Useful heat value) greater than 6200 kcal/kg
	B	UHV 5600-6200 kcal/kg
	C	UHV 4940-5600 kcal/kg
	D	UHV 4200-4940 kcal/kg
	E	UHV 3360-4200 kcal/kg
	F	UHV 2400-3360 kcal/kg
	G	UHV 1300-2400 kcal/kg
Non-coking coal produced in the states of Arunachal Pradesh, Assam, Meghalaya, and Nagaland	Not graded	
Coking coal		
Steel	I	Ash content not exceeding 15%
Steel	II	Ash content greater than 15% but less than 18%
Washery	I	Ash content greater than 18% but less than 21%
Washery	II	Ash content greater than 21% but less than 24%
Washery	III	Ash content greater than 24% but less than 28%
Washery	IV	Ash content greater than 28% but less than 35%
Semi-coking and weakly coking coals		
Semi-coking	I	Ash plus moisture content not exceeding 19%
Semi-coking	II	Ash plus moisture content greater than 19% but not exceeding 24%
Long-flame coal produced in collieries in all the states excepting Assam, Arunachal Pradesh, Meghalaya, Nagaland, and the Singareni Collieries in Andhra Pradesh	A	UHV greater than 6200 kcal/kg
	B	UHV greater than 5600 kcal/kg but not exceeding 6200 kcal/kg
	C	UHV greater than 4940 kcal/kg but not exceeding 5600 kcal/kg
	D	UHV greater than 4200 kcal/kg but not exceeding 4940 kcal/kg
Hard coke		
By-product	Premium	Ash content not exceeding 25%
By-product	Ordinary	Ash content greater than 25% but not exceeding 30%
Beehive	Premium	Ash content not exceeding 27%
Beehive	Superior	Ash content greater than 27% but not exceeding 31%
Beehive	Ordinary	Ash content greater than 31% but not exceeding 36%

Notes

1 Coking coals have been classified thus by the erstwhile Coal Board under the Coal Mines (Conservation, Safety, and Development) Act, 1952 (12 of 1952) (since repealed) or such coals as have been declared or may be declared as coking coal by the central government under the Colliery Control Order, 1945, or the Coal Mines (Conservation and Development) Act, 1974 (28 of 1974), and the rules made under both the aforesaid Acts.

2 Semi-coking coals and weakly-coking coals are classified as 'blendable coals' by the erstwhile Coal Board under the Coal Mines (Conservation, Safety, and Development) Act, 1952 (12 of 1952) (since repealed), or as may be declared as 'semi-coking' or 'weakly coking' coals by the central government under the Colliery Control Order, 1945, or the Coal Mines (Conservation and Development) Act 1974 (28 of 1974), and the rules made under both the aforesaid Acts.

3 Coals other than coking, semi-coking, or weakly-coking coals are non-coking coals.

4 UHV is defined by the formula. UHV in kcal/kg = (8900 - 138 x [percentage of ash content + percentage of moisture content]). In the case of coal having moisture less than 2% and volatile content less than 19%, the UHV shall be the value arrived as above, reduced by 150 kcal/kg for each 1% reduction in volatile content below 19% fraction pro-rata. Both moisture and ash shall be determined after equilibrating at 60% relative humidity and 40 °C temperature as per relevant clauses of the Indian Standard Specification No. IS:1350-1959.

5 Ash percentage of coking coals and hard coke shall be determined after air-drying as per IS:1350-1959. If the moisture so determined is more than 2%, the determination shall be after equilibrating at 60% relative humidity at 40 °C as per IS:1350-1959.

6 Long-flame coals shall be defined by the parameters as laid down in Table II of the Indian Standard Specification No. IS:770-1964, 'General classification of coals (Revised)'. The volatile matter (on unit coal basis) present in these coals exceeds 32%.

7 The above classification shall not apply to coals other than bituminous or sub-bituminous coals as specified under the Indian Standard Specification No. IS:77-1964.

Source

MoC. 1995. **The Gazette of India.** Extraordinary, Part II, Section 3, Sub-section (ii), No. 718. pp. 3-4. New Delhi: Ministry of Coal. 5 pp.

Table 1.16 Comparison of GCV (gross calorific value) and UHV (useful heat value) for non-coking coal (with six per cent moisture content)

	UHV (kcal/kg)		*Ash* (%)		*GCV* (kcal/kg)	
Grade	*From*	*To*	*From*	*To*	*From*	*To*
A	–	>6200	–	<13.56	–	>6406
B	5600	6200	13.56	17.91	5997	6406
C	4940	5600	17.91	22.69	5447	5997
D	4200	4940	22.69	28.06	5042	5447
E	3360	4200	28.06	34.14	4469	5042
F	2400	3360	34.14	41.10	3814	4469
G	1300	2400	41.10	49.07	3064	3814

Source

TERI. 1997. **Relative economics of fuels in power generation**. TERI Report No. 96PG64. New Delhi: Tata Energy Research Institute.

Table 1.17 Production from coal washeries (**million tonnes**): 1990/91 to 1999/2000

Feed and production	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Prime coking coal										
Raw coal feed	12.47	12.57	12.05	12.95	13.30	13.09	12.8	–	–	–
Clean coal production	6.44	6.78	6.54	6.69	6.88	6.76	5.9	4.5	–	–
Middling production	3.08	3.47	3.48	3.70	3.52	4.00	3.7	–	–	–
Medium coking coal										
Raw coal feed	8.03	9.24	10.44	9.74	9.44	9.91	9.4	–	–	–
Clean coal production	4.73	5.16	5.56	5.43	4.87	5.10	5.0	5.4	–	–
Middling production	2.46	2.60	2.98	2.91	2.81	2.80	3.1	–	–	–
Total										
Raw coal feed	20.50	21.81	22.49	22.69	22.74	23.00	22.2	22.0	21.1	19.0
Clean coal production	11.10	12.00	12.10	12.12	11.75	11.90	10.9	10.0	9.7	9.3
Middling production	5.60	6.07	6.46	6.61	6.33	6.80	6.8	7.5	7.2	6.1

Sources

1 CCO. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

2 MoC. 1998. ***Annual Report 1997/98***. New Delhi: Ministry of Coal.

For more details, please see TEDDY ONLINE+ [Section: Coal (general, production, and despatch)]

Table 1.18 Raw coal feed (**million tonnes**) and clean coal production (**million tonnes**) of washeries: 1993/94 to 1999/2000

Company / Washeries	*Raw coal feed*							*Clean coal production*						
	1993/94	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Bharat Coking Coal Ltd														
Dugda I	1.14	1.09	0.85	0.53	0.01	0.11	0.73	0.54	0.51	0.48	0.26	0	0.07	0.43
Dugda II	1.25	1.25	1.10	1.10	1.22	0.99	1.06	0.60	0.59	0.62	0.48	0.48	0.40	0.48
Bhojudih	1.51	1.61	1.49	1.45	1.49	1.50	1.36	0.98	1.01	0.98	0.86	0.83	0.80	0.83
Patherdih	0.93	1.01	1.02	0.98	0.81	0.73	0.64	0.52	0.62	0.65	0.55	0.34	0.27	0.26
Lodna	0.37	0.34	0.34	0.28	0.25	0.33	0.35	0.20	0.19	0.18	0.14	0.11	0.14	0.16
Sudamdih	0.85	1.02	0.94	0.90	0.84	0.88	0.86	0.34	0.47	0.42	0.39	0.33	0.32	0.36
Barora	0.32	0.33	0.32	0.34	0.36	0.32	0.32	0.12	0.13	0.15	0.14	0.14	0.11	0.18
Moonidih	1.05	1.07	0.99	0.98	1.03	0.92	1.00	0.51	0.55	0.50	0.49	0.51	0.44	0.51
Mohuda	0.36	0.34	0.35	0.37	0.37	0.35	0.36	0.26	0.24	0.24	0.24	0.25	0.22	0.26
Total	7.78	8.06	7.40	6.93	6.38	6.23	7.01	4.07	4.31	4.22	3.55	3.00	2.81	3.60
Central Coalfields Ltd														
Kargali	2.44	2.18	2.04	1.94	1.72	1.60	0.15	1.35	1.05	1.01	1.02	0.79	0.69	0.06
Kathara	1.83	1.76	1.73	1.55	1.62	1.71	1.15	0.82	0.78	0.72	0.61	0.55	0.55	0.54
Swang	0.99	0.99	0.97	0.81	0.71	0.79	0.71	0.70	0.60	0.61	0.46	0.41	0.43	0.36
Gidi	1.80	1.79	1.95	1.64	1.79	0.16	0	0.96	0.92	0.93	0.68	0.62	0.04	0
Rajrappa	1.71	1.70	2.18	2.42	2.13	2.13	2.06	0.97	0.90	1.23	1.39	1.01	0.98	0.80
Kedla	0	0	0	0.01	0.62	1.00	0.86	0	0	0	0	0.25	0.39	0.34
Total	8.77	8.42	8.87	8.37	8.59	7.39	4.93	4.80	4.24	4.50	4.15	3.63	3.08	2.11
Western Coalfields Ltd														
Nandan	0.61	0.68	0.69	0.65	0.68	0.66	0.62	0.37	0.39	0.42	0.41	0.39	0.35	0.30
Coal India Ltd														
Durgapur Steel Plant	17.16	17.16	16.96	15.95	15.65	14.28	12.56	9.24	8.94	9.14	8.11	7.02	6.24	6.00
Durgapur Steel Plant Washery	0.47	0.41	0.24	0.12	0.14	0.41	0.26	0.30	0.27	0.19	0.09	0.10	0.31	0.20
Durgapur Power Ltd														
Durgapur Power Limited Washery	0.01	0.01	0	0	0	0	0	0.01	0.01	0	0	0	0	0
Indian Iron and Steel Company														
Chasnala	1.16	1.11	1.00	0.85	1.03	1.14	0.91	0.59	0.58	0.54	0.50	0.58	0.63	0.50
Total	1.64	1.53	1.24	0.97	1.17	1.55	1.18	0.90	0.85	0.73	0.59	0.68	0.68	0.70
Private sector	18.80	18.69	18.20	16.92	16.85	15.83	13.74	10.13	9.79	9.87	8.70	7.70	7.20	6.70
Tata Iron and Steel Company														
West Bokaro I	0.61	0.51	0	0	0	0	0	0.34	0.29	0	0	0	0	0
West Bokaro II	1.90	1.78	1.72	1.82	1.87	1.87	1.91	0.72	0.67	0.62	0.66	0.69	0.77	0.76
West Bokaro III	0	0.43	1.81	2.13	2.07	1.94	1.94	0	0.16	0.63	0.75	0.74	0.71	0.72
Jamadoba	1.38	1.33	1.27	1.36	1.24	1.43	1.45	0.93	0.84	0.80	0.78	0.88	1.07	1.08
Total	3.89	4.05	4.80	5.31	5.18	5.24	5.30	1.99	1.96	2.05	2.19	2.31	2.55	2.56
Grand total	22.69	22.74	23.00	22.23	22.00	21.07	19.04	12.12	11.75	11.92	10.89	10.01	9.72	9.26

Source

CCO. *Coal Directory of India* (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

Table 1.19 Inter-modal split of coal movement: 1977/78 to 2000/01

	1977/78		*1995/96*		*1996/97*		*1997/98*		*1998/99*		*1999/2000*		*2000/01*[a]	
Mode	*MT*	*%*	*MT*	*%*	*MT*	*%*	*MT*	*%*	*MT*	*%*	*MT*	*%*	*MT*	*%*
Rail	78	78	156	56	165	57	176	57.14	164	54.85	179	55.94	136	56.67
Road	17	17	54	19	52	18	54	17.53	53	17.73	54	16.88	38	15.83
Belt	2	2	6	2	6	2	9	2.92	11	3.68	8	2.50	6	2.50
Ropeway	1	1	6	2	5	2	6	1.95	6	2.01	10	3.13	6	2.50
Merry-go-round	2	2	56	21	59	21	63	20.45	65	21.74	69	21.56	54	22.50
Total	100	100	280	100	287	100	308	100.00	299	100.00	320	100.00	240	100.00

MT – million tonnes

[a] April–December

Source

MoC. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Coal.

Table 1.20 Capacity and traffic handled at major ports (million tonnes): 1999/2000

	Capacity		*Traffic handled*	
Port	*All commodity*	*Only coal*	*All commodity*	*Only coal*
Chennai	27.6	–	37.4	9.7
Haldia	28.7	6.8	20.7	6.5
Jawaharlal Nehru	14.6	–	15.0	–
Kandla	39.0	–	46.3	0.8
Kochi	13.5	–	12.8	0.2
Kolkata	8.3	–	10.3	–
Marmagao	19.5	–	18.2	0.7
Mumbai	30.5	–	30.4	–
New Mangalore	20.2	–	17.6	0.1
Paradip	12.8	4.8	12.8	7.5
Tuticorin	12.5	5 2	10.0	3.6
Visakhapatnam	30.8	–	39.5	8.1

Source

MoST. 2000. ***Basic Port Statistics of India 1999/2000***. New Delhi: Ministry of Surface Transport.

Table 1.21 Average cost of production (**rupees per tonne**) of the CIL (Coal India Ltd) and the SCCL (Singareni Collieries Company Ltd) coal: 1993/94 to 1998/99

	Average cost of production	
Year	*CIL*	*SCCL*
1993/94	364.4	487.00
1994/95	380.5	543.00
1995/96	412.7	643.00
1996/97	442 1	731.56
1997/98	480.8	775.78
1998/99	502 4	826.30

Source
MoC. 2000. ***Annual Report 1999/2000***. New Delhi: Ministry of Coal.

Table 1.22 Average pithead unit value (**rupees per tonne**) of coal: 1974/75 to 1997/98

Year	*Pithead unit value*
1974/75	70.42
1979/80	118.95
1984/85	206.88
1989/90	278.51
1990/91	277 89
1991/92	354.90
1992/93	355.41
1993/94	433.21
1994/95	442.00
1995/96	505.50
1996/97	576.00
1997/98	600.30

Note
The figures are up to March for all the years.

Source
CCO. ***Coal Directory of India*** (various issues).
Kolkata: Coal Controller's Organization, Ministry of Coal.

Table 1.23 Average pithead prices (**rupees per tonne**) of the CIL (Coal India Ltd) and the SCCL (Singareni Collieries Company Ltd) coal: 1991 to 1999

	Average pithead price	
Date of revision	*CIL*	*SCCL*
27 December 1991	322.00	388.00
17 February 1993	364.00	434.00
19 June 1993	381.00	452.00
01 April 1994	381.00	482.00
17 June 1994	401.00	503.00
01 April 1996	469.00	503.00
19 April 1996	469.00	530.00
20 October 1996	498.54	530.00
12 November 1996	498.54	529.42
19 March 1997	498.54	710.59
01 April 1997	553.37	710.59
01 October 1997	559.02	710.59
21 August 1998	586.19	710.59
29 August 1998	586.19	753.31
05 January 1999	590.05	753.31
31 May 1999	595.84	753.31
19 September 1999	595.84	775.62

Source
MoC. 2000. ***Annual Report 1999/2000***. New Delhi: Ministry of Coal.

Table 1.24 Annual average import price of coal (**dollars per tonne**): 1994 to 1997

Country	*1994*	*1995*	*1996*	*1997*[a]
Australia	32.30	39.37	38.07	35.4
USA	36.48	39.19	37.21	36.5

[a] January–December

Note
Coal (Australian), thermal, 12 000 btu/lb, less than 1% sulphur, 14% ash, free-on-board piers, Newcastle/Port Kembla
Coal (US), thermal, 12 000 btu/lb, less than 1% sulphur, 12% ash, free-on-board piers, Hampton Road/Norfolk

Table 1.25 Customs duty structure on imported coal: 2000/01

Import of coal	*Current duty*
Coking coal	
Ash content less than 12%	5% basic customs duty
Ash content greater than 12%	15%
Non-coking coal	25%

Source
MoC. 2001. *Annual Report 2000/01*. New Delhi: Ministry of Coal

Table 1.26 Royalty (**million rupees**) paid on coal by states: 1991/92 to 1998/99

Year	*West Bengal*	*Bihar*	*Orissa*	*Maharashtra*	*Madhya Pradesh*	*Uttar Pradesh*	*Assam*	*Andhra Pradesh*	*Total*
1991/92	100.1	3178	435	610	2402	475	6.4	354	7561
1992/93	87.2	5043	631	1089	3845	668	5.4	1000	12369
1993/94	106.3	5551	728	1111	3696	706	4.4	2913	14815
1994/95	95.9	6131	1041	1597	4389	874	4.2	1445	15577
1995/96	78.2	6583	1808	2179	6668	1135	215.9	1753	20420
1996/97	108.7	6828	1854	2003	6841	1214	99.2	1971	20919
1997/98	126.4	6590	2276	2048	6636	1024	61.1	2781	21542
1998/99	97.6	6079	2289	1846	6751	868	51.7	2002	19984

Source
MoC. 2000. *Annual Report 1999/2000*. New Delhi: Ministry of Coal.

Table 1.27 Revised rates of royalty (**rupees per tonne**)

Coal group	*Royalty from 1 August 1991*	*Royalty from 11 October 1994*
Group-I (Coking coal SG I II, WG I)	150	195
Group-II (Coking coal WG II, III, SC I II Non-coking A, B)	120	135
Group-III (Coking coal WG IV, Non-coking C)	75	95
Group-IV (Non-coking D, E)	45	70
Group-V (Non-coking F, G)	25	50
Group-VI (Coal produced in Andhra Pradesh)	70	75

Note
Royalty has not been revised since 1994.

Source
MoC. 2000. *Annual Report 1999/2000*. New Delhi: Ministry of Coal.

Table 1.28 Selling price of coal in respect of the CIL (Coal India Ltd) and subsidiaries (rupees per tonne): 31 January 2001

Subsidiary	*Characteristics*	*Grade*	*Steam coal and rubble*	*Slack coal and washery middlings*	*Run-of-mine coal*
Non-coking coal					
Eastern Coalfields Ltd (Ranigunj)	Coal produced in Annexure I collieries	A	1538	1400	1388
		B	1462	1323	1312
		C	1268	1130	1118
		D	1055	912	905
Coal produced in other collieries of Ranigunj Coalfields	Long-flame coal	A	1413	1273	1263
		B	1342	1202	1192
		C	1168	1028	1018
		D	974	830	824
	Non-long-flame coal	A	1334	1194	1184
		B	1265	1125	1115
		C	1089	949	939
		D	898	754	748
		E	674	530	524
		F	567	423	417
		G	448	304	298
Eastern Coalfields Ltd (Salanpur)	Non-long-flame coal	A	1327	1187	1177
		B	1209	1069	1059
		C	1020	881	870
		D	844	700	694
		E	674	530	524
		F	567	424	417
		G	448	305	298
Eastern Coalfields Ltd (SP Mines)	Coal produced in Annexure I collieries	A	1469	1330	1319
		B	1342	1203	1192
		C	1146	1007	996
		D	960	816	810
Eastern Coalfields Ltd (SP Mines)	Long-flame coal	A	1349	1210	1199
		B	1235	1096	1085
		C	1055	916	905
		D	885	742	735
	Non-long-flame coal	A	1270	1130	1120
		B	1187	1017	1007
		C	978	838	828
		D	810	666	660
		E	674	530	524
		F	567	423	417
		G	448	304	298

Continued

Table 1.28 continued

Subsidiary	*Characteristics*	*Grade*	*Steam coal and rubble*	*Slack coal and washery middlings*	*Run-of-mine coal*
Eastern Coalfields Ltd (Mugma)	Long-flame coal	A	1349	1209	1199
		B	1235	1095	1085
		C	1055	915	905
		D	885	741	735
	Non-long-flame coal	A	1270	1131	1120
		B	1157	1018	1007
		C	978	839	828
		D	810	666	860
		E	674	530	524
		F	567	424	417
		G	448	305	298
Eastern Coalfields Ltd (Rajmahal Project)	Long-flame coal	D	1065	921	915
	Non-long-flame coal	E	853	710	703
		F	747	604	597
		G	629	485	479
Western Coalfields Ltd	Long-flame coal	A	1233	1093	1083
		B	1172	1032	1022
		C	1105	965	955
		D	1052	908	902
	Non-long-flame coal	A	1187	1027	1017
		B	1106	966	958
		C	1040	900	890
		D	985	841	835
		E	858	714	708
		F	740	596	590
		G	595	451	445
South-Eastern Coalfields Ltd	Coal produced in Annexure I collieries	A	1250	1111	1100
		B	1184	1045	1034
		C	1012	873	862
		D	886	742	736
	Long-flame coal	A	1149	1009	999
		B	1089	949	939
		C	934	794	784
		D	819	675	669
	Non-long-flame coal	A	1084	944	934
		B	1022	882	872
		C	867	727	717
		D	750	606	600
		E	647	503	497
		F	564	402	396
		G	433	289	283

Continued

Table 1.28 continued

Subsidiary	*Characteristics*	*Grade*	*Steam coal and rubble*	*Slack coal and washery middlings*	*Run-of-mine coal*
Central Coalfields Ltd	Long-flame coal	A	1327	1187	1177
		B	1215	1075	1065
		C	1040	900	890
		D	908	764	758
	Non-long-flame coal	A	1250	1110	1100
		B	1139	999	989
		C	963	823	813
		D	830	686	680
		E	689	545	539
		F	581	437	431
		G	458	314	308
Bharat Coking Coal Ltd	Long-flame coal	A	1271	1131	1121
		B	1164	1024	1014
		C	997	857	847
		D	872	728	722
	Non-long-flame coal	A	1197	1057	1047
		B	1092	952	942
		C	924	784	774
		D	798	654	648
		E	664	520	514
		F	560	416	410
		G	444	300	294
Northern Coalfields Ltd	Long-flame coal	A	1297	1157	1147
		B	1189	1049	1039
		C	1017	877	867
		D	890	746	740
	Non-long-flame coal	A	1222	1082	1072
		B	1114	974	964
		C	942	802	792
		D	814	670	664
		E	677	533	527
		F	570	426	420
		G	450	306	300
Mahanadi Coalfields Ltd	Long-flame coal	A	1129	989	979
		B	1035	895	885
		C	890	750	740
		D	783	639	633
	Non-long-flame coal	A	1062	922	912
		B	969	829	819
		C	824	684	674
		D	716	572	566
		E	595	451	445
		F	501	357	351
		G	400	256	250

Continued

Table 1.28 continued

Subsidiary	*Characteristics*	*Grade*	*Steam coal and rubble*	*Slack coal and washery middlings*	*Run-of-mine coal*
Coking coal					
Bharat Coking Coal Ltd	Steel	I	2064	1924	1914
(For collieries listed in Annexure III)	Steel	II	1748	1608	1598
	Washery	I	1535	1395	1385
	Washery	II	1297	1157	1147
	Washery	III	998	858	848
	Washery	IV	939	799	789
Bharat Coking Coal Ltd	Steel	I	1845	1705	1695
	Steel	II	1566	1426	1416
	Washery	I	1377	1237	1227
	Washery	II	1166	1026	1016
	Washery	III	901	761	751
	Washery	IV	849	709	699
Eastern Coalfields Ltd	Washery	I	1462	1322	1312
	Washery	II	1237	1098	1087
	Washery	III	953	814	803
	Washery	IV	897	758	747
Central Coalfields Ltd	Washery	I	1437	1297	1287
	Washery	II	1217	1077	1067
	Washery	III	939	799	789
	Washery	IV	884	744	734
South-Eastern Coalfields Ltd	Washery	I	1246	1106	1096
	Washery	II	1057	917	907
	Washery	III	821	681	671
	Washery	IV	775	635	625
Western Coalfields Ltd	Washery	I	1225	1085	1075
	Washery	II	1040	900	890
	Washery	III	953	813	803
	Washery	IV	809	669	659
Bharat Coking Coal Ltd	Semi-coking	I	1485	1345	1335
(For collieries listed in Annexure III)	Semi-coking	II	1258	1116	1106
Bharat Coking Coal Ltd	Semi-coking	I	1333	1193	1183
	Semi-coking	II	1129	989	979
Eastern Coalfields Ltd	Semi-coking	I	1510	1371	1360
(Raniganj)	Semi-coking	II	1276	1136	1126
Central Coalfileds Ltd	Semi-coking	I	1391	1251	1241
	Semi-coking	II	1177	1037	1027
All subsidiaries	Semi-coking	I	1246	1106	1096
	Semi-coking	II	1057	917	907

Source

CIL. 2001. **Sales and Marketing: 2000. Price list January 2001**. New Delhi. Coal India Ltd.

Table 1.29 Plan expenditure and the share of coal and total energy (**million rupees**)

Five-Year Plan	*Plan expenditure*[a]	*Share of coal*	*Total energy*[b]
First (1951-56)	19 600	–	3 861.2 (19.7)
Second (1956-61)	26 700	507.3 (1.9)	3 310.8 (12.4)
Third (1961-66)	85 800	1 115.4 (1.3)	15 873.0 (18.5)
Fourth (1969-74)	157 800	1 104.6 (0.7)	33 453.6 (21.2)
Fifth (1974-79)	394 300	11 434.7 (2.9)	99 363.6 (25.2)
Sixth (1980-85)	1 092 900	38 251.5 (3.5)	307 104.9 (28.1)
Seventh (1985-90)	2 202 200	70 470.4 (3.2)	621 020.4 (28.2)
Eighth (1992-97)[c]	4 341 000	104 184 0 (2.4)	1 150 365.0 (26.5)

[a] expenditure at current prices at the base year of the respective plans

[b] total energy includes power, coal, oil and gas, and new and renewable energy sources

[c] outlay

Note

Figures in parentheses are percentages.

Source

Ninth Five-Year Plan. 1997–2002. **Volume II. Thematic Issues and Sectoral Programmes.**
New Delhi: Planning Commission, Government of India.

Table 1.30 Annual Plan expenditure during the Eighth Five-Year Plan and actual expenditure (**million rupees**)

Year	*Coal India Ltd*	*Singareni Collieries Company Ltd*	*Science and technology regional exploration and others*
1993/94			
Budget estimate	19 010.0	6422.0	170.0
Revised	17 200.0	5600.0	170.0
Actual expenditure	16 879.2	5449.8	159.1
1994/95			
Budget estimate	20 629.0	4834.0	235.0
Revised	18 500.0	5500.0	229.9
Actual expenditure	16 045.6	5165.8	48.4
1995/96			
Budget estimate	22 600.0	5160.0	438.2
Revised	12 037.8	3357.5	251.0
Actual expenditure	15 036.3	2593.5	147.9
1996/97			
Budget estimate	21 430.0	5389.7	528.0
Revised	13 108.3	3250.0	280.0
Actual expenditure	15 304.5	2500.6	280.7
1998/99			
Budget estimate	25 172.0	3315.7	921.3
Revised	17 000.0	2800.0	571.0
Actual expenditure	17 537.3	2004.9	448.0
1999/2000			
Budget estimate	25 560.0	2271.9	825.4
Revised	26 761.9	2172.0	631.4
Actual expenditure	28 042.8	1410.7	560.0
2000/01			
Budget estimate	27 903.2	3278.2	3612.2
Revised	17 670.0	2350.0	2385.0
Actual expenditure	8 408.4	722.2	150.0

Source

MoC 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Coal.

Table 1.31 Net budgetary support as percentage of actual plan expenditure in coal: 1992/93 to 1996/97

Year	*Net budgetary support* (%)
1992/93	13.54
1993/94	8.50
1994/95	12.55
1995/96	12.59
1996/97	7.41

Source
MoC. 2000. ***Annual Report 1999/2000***. New Delhi: Ministry of Coal.

Table 1.32 Availability and estimated sectorwise consumption of raw coal (**million tonnes**): 1990/91 to 1997/98

Items	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Availability								
Production	213.90	232.80	242.00	248.68	257.8	273.4	286.1	297.2
Imports[a]	5.71	5.92	6.26	7.10	8.3	8.9	9.5	9.5
Exports	0.10	0.11	0.13	0.10	0.1	0.1	0.1	0.1
Pithead stock (opening)	37.64	42.47	48.53	51.39	50.8	47.5	45.6	42.0
Pithead stock (closing)	42.47	48.53	51.31	50.75	47.5	45.6	42.0	41.5
Adjustment of pithead stock								
Industrial stock (opening)	6.21	5.25	5.50	0	0	0	0	0
Industrial stock (closing)	5.25	5.48	0	0	0	0	0	0
Available for industrial consumption after adjustment of off-take	213.30	228.87	241.79	255.90	269.2	284	299	307.1
Consumption/supply (raw coal)								
Steel and washery	30.91	34.03	37.30	37.63	38.6	39.1	39.8	39.8
Railways	5.24	5.06	4.34	2.00	0.67	0.3	0.1	0.1
Electricity (excluding middlings)	113.71	126.84	138.57	154.41	160.9	184.5	199.6	205.5
Cement	10.43	10.80	11.70	11.07	12.4	11.1	10.1	10.1
Cotton	2.58	1.96	1.90	1.81	1.8	1.2	1.3	1.3
Jute	0.12	0.12	0	0	0	0.1	0.1	0
Paper[b]	2.81	2.67	2.56	2.90	3.2	3.2	3.5	3.4
Brick	1.71	1.75	1.65	1.54	1.0	0.9	1.0	1.6
Coal for soft coke	1.20	1.03	0.97	0.44	0.3	0.3	0.3	0
Other industries	40.58	40.51	38.71	39.53	46.7	40.0	39.8	42.1
Colliery consumption	4.07	4.10	3.99	4.71	3.7	3.5	3.4	3.1
Total consumption	213.30	228.87	241.75	255.90	269.3	284.2	299.0	307.1

[a] only coking coal imports
[b] includes only rail despatches

Source
CCO. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.
For more details, please see TEDDY ONLINE+ [Section: Coal (general)]

Table 1.33A Supply (thousand tonnes) of coal to steel plants: 1996/97 to 1997/98

Steel plant	1996/97					1997/98				
	Prime coking coal	*Medium coking coal*	*Blendable coking coal*	*Total*	*Boiler coal*	*Prime coking coal*	*Medium coking coal*	*Blendable coking coal*	*Total*	*Boiler coal*
Steel Authority of India Ltd										
Bhilai Steel Plant	892.4	1273.2	205.0	2370.6	779.4	893	1084	165	2142	760
Bokaro Steel Plant	900.1	1252.1	0	2153.0	1602.9	901	1204	0	2105	1483
Durgapur Steel Plant	622.0	448.6	8.7	1079.3	549.3	532	396	0	928	671
Indian Iron and Steel Company	777.1	419.3	73.6	1270.0	248.1	636	356	42	1034	209
Rourkela Steel Plant	356.2	714.1	0	1070.3	1302.2	344	570	0	914	1364
Total	3547.8	4108.1	287.3	7943.2	4481.9	3306	3610	207	7123	4487
Tata Iron and Steel Company Ltd	378.0	590.0	17.0	985.0	1474.2	900	1427	3	2330	1450
Visakapatnam Steel Plant	75.7	750.5	0	826.2	1351.8	0	619	0	619	1434
Grand total	4001.5	5448.6	304.3	9754.4	7307.9	4206	5656	210	10072	7371

Source
CCO. 2000. ***Coal Directory of India 1999/2000***. Kolkata: Coal Controller's Organization, Ministry of Coal.

Table 1.33B Supply (**thousand tonnes**) of coal to steel plants: 1998/99 to 1999/2000

Steel plant	*1998/99* Prime coking coal	Medium coking coal	Blendable coking coal	Total	Boiler coal	*1999/2000* Prime coking coal	Medium coking coal	Blendable coking coal	Total	Boiler coal
Steel Authority of India Ltd										
Bhilai Steel Plant	748	1,112	32	1,892	704	782	796	–	1,578	913
Bokaro Steel Plant	854	1085	–	1939	1398	865	965	–	1830	1626
Durgapur Steel Plant	686	405	6	1097	624	664	319	–	1055	589
Indian Iron and Steel Company	659	257	48	964	175	641	300	42	983	135
Rourkela Steel Plant	360	590	–	950	1292	456	482	–	938	1151
Total	3307	3449	86	6842	4193	3408	2934	42	6384	4414
Tata Iron and Steel Company Ltd	1079	1479	–	2558	1400	1013	1349	–	2362	1222
Visakapatnam Steel Plant	–	386	–	386	1721	–	–	–	–	1351
Grand total	4386	5314	86	9786	7314	4421	4283	42	8746	6987

Source

CCO. 2000. ***Coal Directory of India 1999/2000***. Kolkata: Coal Controller's Organization, Ministry of Coal.

Table 1.34 Sectoral offtake from the CIL (Coal India Ltd) and the SCCL (Singareni Collieries Company Ltd) **(million tonnes)**: April-December 1999/2000

	CIL			*SCCL*		
Sector	*Target offtake*	*Actual offtake*	*Supply* (%) *against target*	*Target offtake*	*Actual offtake*	*Supply* (%) *against target*
Power	136.74	141.000	103	16.76	17.90	106.8
Steel	14.12	10.950	78	0	0	0
Locomotive	0	0.007	100	0	0	0
Cement	4.36	4.810	110	2.32	2.32	100.0
Fertilizer	2.79	2.390	86	0.44	–	-100.0
Others	29.58	28.990	98	2.68	1.91	71.3
Colliery consumption	1.93	1.670	86	0.26	0.22	84.6

Source
MoC. 2000. ***Annual Report 1999/2000***. New Delhi: Ministry of Coal.

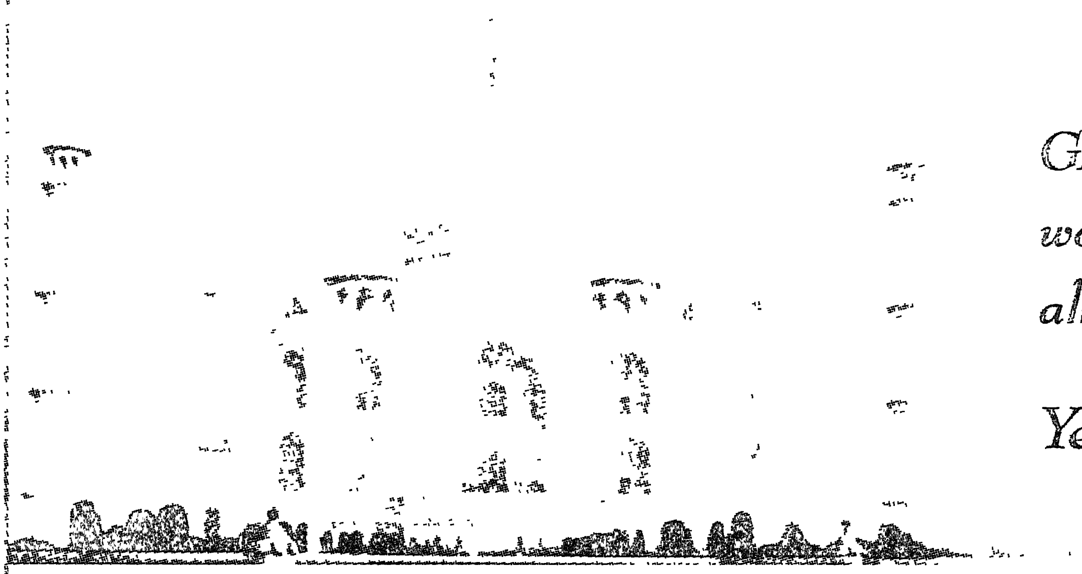
"Earth provides enough to satisfy
every man's need,
but not for every man's greed."

(Mahatma Gandhi)

Committed to a clean environment...
in thought & deed.

इंडियनऑयल

Indian Oil Corporation Limited



GAIL at work here also ?

Yes, of course!

Protecting the environment through Natural Gas supply in the Agra-Firozabad belt.

When alarming air pollution threatened to ruin the fair face of the Taj, GAIL stepped in right earnest to restore the situation. It took up the challenge of laying an extensive Natural Gas supply network to reach this non-polluting fuel to metal foundries and glass manufacturing units located in Agra and Firozabad.

The changeover to Natural Gas was smooth. Not only were ecological concerns addressed, but the economy and employment avenues were also saved. Thanks to the corporate culture at GAIL which is well tuned to the demands of the environment, the society and the economy.

It is this culture that drives GAIL in everything it takes up; whether setting up a cross-country pipeline network, a petrochemical complex or LPG plants. And, delivering perfect performance year after year.

Gas Authority of India Ltd.

(A Government of India Undertaking)

16, Bhikaiji Cama Place, R K Puram, New Delhi - 110 066 Phones 011-6172580, 6182955 Fax · 011-6185941

Visit us at http://www.gailindia.com, http://gail.nic.in

Employees
Our strength

Team Spirit
Our forte

Challenges
Our motivation

New Heights
Our endeavour

The Globe
Our horizon

Our business
Oil & Gas

Exploration

Production

Transportation

LPG Production

ऑयल इंडिया लिमिटेड
(भारत सरकार का उपक्रम)

Oil India Limited

(A Govt. Of India Enterprise)
Allahabad Bank Building
17, Sansad Marg, New Delhi - 110001
E-mail: oilindia@oil.delhi.nic.in
Website: www@oilindia.nic.in
Phone Nos. 3360841, 3360675, 3340844

Century of aggressive past ... Centuries of progressive future

Oil and gas

At a glance

- India's balance recoverable reserves for crude oil and gas stand at 658 million tonnes and 628 billion cubic meters.
- Crude oil and gas production for 1999/2000 aggregated 31.95 million tonnes and 26.45 billion cubic metres, respectively, with the private sector accounting for about 12% of the total output.
- Twenty-three blocks awarded under the second round of New Exploration Licensing Policy.
- Restructuring of refining sector complete; government equity in Kochi Refineries Ltd and Numaligarh Refinery Ltd divested in favour of Bharat Petroleum Corporation Ltd and that in Chennai Petroleum Corporation Ltd and Bongaigaon Refineries and Petrochemicals Ltd in favour of Indian Oil Corporation Ltd.
- Petroleum products consumption falls by about 0.5% with the slowdown in the economy. Diesel sales decline by as much as four per cent.
- Feasibility studies for viability of gas imports by pipeline from Iran through Pakistan initiated.
- Uncertainty regarding the fate of Dabhol liquefied natural gas terminal with Enron backing out of the project.

Exploration and production

Overview

The 26 sedimentary basins of India account for 1.35 million km^2 of onshore area and 0.39 million km^2 of offshore area (up to 200 m isobath water depth). The country has a total prognosticated resource base of 21 billion tonnes, with an additional 9 billion tonnes from deep-water areas. Of this, only 6.8 billion tonnes of geological reserves have been established through exploration, leaving two-thirds of the area unexplored. Balance recoverable reserves for oil, as on April 2000, stood at 658 MMT (million tonnes) (MoPNG 2000).

Exploration and production of oil and gas have been primarily in the hands of two national oil companies: the ONGC (Oil and Natural Gas Corporation) and the OIL (Oil India Ltd). Over the years, the domestic availability of crude oil has not kept pace with demand. Self-reliance on crude oil has dropped dramatically over the last couple of years with the spurt in refining capacity and presently stands at a mere 30%. Figure 1 presents a snapshot of this growing imbalance.

High import dependence for crude oil constitutes a major drain on the country's foreign exchange reserves. While there is an urgency in enhancing indigenous crude oil production, the resource requirements for the same are prohibitive. The need to attract private capital for the development of domestic resources is increasingly imminent.

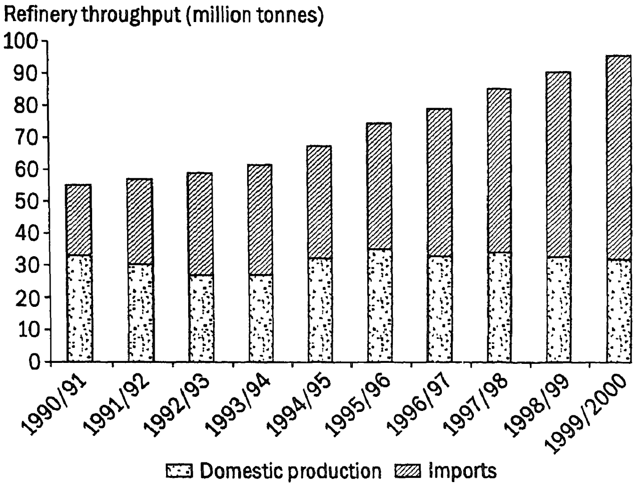


Figure 1 Trends in self reliance in petroleum
Source MoPNG (2000)

Table I Oil and gas production by NOCs (national oil companies) and private and joint venture companies

	Oil (MMT)			*Gas* (BCM)		
Year	*NOCs*	*Pvt./JV*	*Total*	*NOCs*	*Pvt./JV*	*Total*
1995/96	34.5	0.7	35.2	22.3	0.3	22.6
1996/97	31.6	1.3	32.9	22.7	0.5	23.3
1997/98	31.3	2.5	33.9	24.7	1.7	26.4
1998/99	29.7	3.0	32.7	24.6	2.9	27.4
1999/2000	27.9	4.0	31.9	25.0	3.5	28.4

Pvt./JV - Private/joint venture
Source MoPNG (2000)

Private sector participation

Exploration bidding rounds to attract private investment started in 1979, far before the reforms of the 1990s, but the early rounds were not successful. The first four rounds were spaced over 12 years (1979–91). The next five rounds came in two years (1994/95) and succeeded in generating some interest in the international oil industry. To increase this interest, the government decided to award some small- and medium-sized fields for development to the private and joint sectors respectively. An innovation was also introduced in the ninth round – known as the JV (joint venture) round – to reduce the risk for the private investors by associating ONGC/OIL as partners in these exploration ventures. The total investment by the private sector in these is estimated to be in excess of 2 billion dollars. In 1999/2000, private and JV companies accounted for about 12% of the total domestic production of oil and gas. Trends in the production of oil and gas by the private sector are summarized in Table I.

To boost domestic oil and gas production, the government also announced the NELP (New Exploration Licensing Policy) in 1997. The NELP includes the following positive features.

- No mandatory state participation
- Competitive bidding of blocks by NOCs (national oil companies) as against nomination basis
- Carried interests of NOC abolished
- Exemption from payment of cess
- Incentives for deep-water exploration
- Seven-year tax holiday from date of commercial production.

The first round of NELP attracted 45 bids for 27 blocks, from which the MoPNG approved the award of 25 blocks. PSCs (production sharing contracts) for 25 blocks were signed in April 2000. The government announced the second round of NELP in December 2000. Details of blocks on offer under NELP rounds are summarized in Table II.

Thirteen companies participated in the second round of NELP. Foreign bidders included Cairns Energy of Britain, Petrom of Romania, Niko Resources of Canada, Joshi Technologies of the US, Hardy Oil and Heramec Ltd of UK, while domestic bidders were the ONGC, the OIL, IOC (Indian Oil Corporation), GAIL (Gas Authority of India Limited), the GSPCL (Gujarat State Petroleum Company Limited), the RPL (Reliance Petroleum Ltd), and the HOEC (Hindustan Oil and Exploration Company).

The government signed PSCs for 23 blocks in the second round of NELP in July 2001. The ONGC and consortia bagged 16 blocks while the Reliance–Hardy Oil combine won 4 blocks. Niko Resources, OIL, and the GSPCL–GAIL–Joshi Tech consortium won one block each. Altogether, the second round witnessed investments of 780 million dollars in three phases, with the first phase investments at 290 million dollars. The government plans to offer the third round of NELP by the end of the current fiscal.

Table II Blocks on offer under the New Exploration Licensing Policy

	First round			*Second round*		
Category	*No. of blocks on offer*	*Bids received for*	*Blocks awarded*	*No. of blocks on offer*	*Bids received for*	*Blocks awarded*
Onshore	10	4	2	9	7	7
Shallow-water offshore	26	16	16	8	8	8
Deep-water offshore	12	7	7	8	8	8
Total	48	27	25	25	23	23

Source MoPNG (2001a)

Refining

Restructuring

The installed refining capacity of the country's 17 refineries totals 112.04 MMTPA (million tonnes per annum) (Table III). A third of the country's refining capacity is in the private/JV sector: the 9.69 MMTPA HPCL (Hindustan Petroleum Corporation Ltd)/AV Birla Group JV at Mangalore, Karnataka, and the 27 MMTPA refinery of Reliance Petroleum Ltd at Jamnagar, Gujarat. The JV refinery at Mangalore, however, has run into rough weather. The AV Birla group has sought permission to exit from the venture. The HPCL, with the first right of refusal, is presently considering picking up a further stake in the project.

Following the recommendations of the Nitish Sengupta Committee on the merger of standalone refining companies with integrated refining-marketing companies, the government sold its stake in the KRL (Kochi Refineries Ltd) and the NRL (Numaligarh Refineries Ltd) to BPCL (Bharat Petroleum Corporation Ltd) and that in the BRPL (Bongaigaon Refineries and Petrochemicals Ltd) and the CPCL (Chennai Petroleum Corporation Ltd) to the IOC. After the restructuring, the IOC accounts for the lion's share of the country's refining capacity with a total capacity of 44.95 MMTPA.

Table III Refining capacity (MMTPA)

Company	*Location*	*State*	*Capacity*
Western Region total			51.9
BPCL	Mumbai	Maharashtra	6.9
HPCL	Mumbai	Maharashtra	5.5
Reliance	Jamnagar	Gujarat	27.0
IOC	Koyali	Gujarat	12.5
Northern Region total			13.5
IOC	Panipat	Haryana	6.0
IOC	Mathura	Uttar Pradesh	7.5
Eastern Region total			8.0
IOC	Barauni	Bihar	4.2
IOC	Haldia	West Bengal	3.8
North Eastern Region total			7.0
IOC	Guwahati	Assam	1.0
IOC	Digboi	Assam	0.7
IOC	Bongaigaon	Assam	2.4
BPCL	Numaligarh	Assam	3.0
Southern Region total			31.7
HPCL	Visakhapatnam	Andhra Pradesh	7.5
HPCL/Indian Rayon	Mangalore	Karnataka	9.7
BPCL	Kochi	Kerala	7.5
IOC	Chennai	Tamil Nadu	6 5
IOC	Narimanam	Tamil Nadu	0 5
Total			112 0

BPCL - Bharat Petroleum Corporation Ltd, HPCL - Hindustan Petroleum Corporation Ltd; IOC - Indian Oil Corporation

Source MoPNG (2000)

Environmental concerns

Pollution control equipment

Effluents from refineries can be classified under three categories: (1) liquid effluents, (2) gaseous emissions, and (3) oily sludge. The government has prescribed MINAS (minimum national standards) for discharge of effluents from refineries with respect to critical parameters such as oil and grease, phenols, sulphides, biochemical oxygen demand, and total suspended solids. All refineries are equipped with full-fledged effluent treatment plants, which ensure that treated waste water fully meets prescribed MINAS.

The control of sulphur dioxide (SO_2) emissions is an important issue. All Indian refineries comply with the SO_2 emission limits applicable to process units. Measures adopted include

- use of low-sulphur fuel oil,
- desulphurization of refinery fuel gas in the sulphur recovery unit, and
- taller stacks for better dispersion.

Oil refineries need a well-planned strategy to manage oily sludge. Typically, oily sludge is dumped into specially constructed pits; however, such systems do not preclude the possibility of seepage. Some refineries – those of the IOC at Mathura and Barauni and BPCL, Mumbai – have adopted *in situ* bioremediation[1] to reclaim contaminated sites. Bioremediation is a process that employs microorganisms capable of degrading toxic contaminants for the reclamation of polluted sites. Contaminants can be treated on-site (*in situ*) through bioremediation, thus ensuring that the contaminant is not merely moved from one place to another.

Fuel quality

Improvement of fuel quality to reduce vehicular air pollution has been a priority area. While phased introduction of unleaded petrol was initiated in April 1995, the entire country is being supplied unleaded petrol only since February 2000. In addition, the sulphur content in MS (motor spirit) has been reduced from 0.2% to 0.15% in March 1997 and further to 0.1% from April 2000 (MoPNG 2001b). Ultra-low-sulphur MS with sulphur content of 0.05% has also been introduced in the four metropolitan cities.

The upper limit for benzene content in MS has been introduced at three per cent for metros and five per cent for the rest of the country with effect from April 2000. In addition, low-benzene MS (one per cent maximum volume) has been introduced in the NCT (National Capital Territory) of Delhi and Mumbai.

To improve the quality of HSD (high speed diesel), nine diesel hydrodesulphurization units have been commissioned in various refineries. The sulphur content in diesel was brought down to 0.25% throughout the country with effect from January 2000. In addition, extra-low-sulphur diesel (sulphur content less than 0.05%) was introduced in select retail outlets in the National Capital Region for newly registered vehicles from April 2000. Since March 2001, all outlets in the NCT sell diesel with sulphur content less than 0.05%.

Marketing and distribution

Marketing of petroleum products can be categorized into two groups: (1) controlled petroleum products such as LPG (liquefied petroleum gas), MS, ATF (aviation turbine fuel),[2] SKO (superior kerosene oil) and HSD; and (2) decontrolled petroleum products. While there are no restrictions on sales of decontrolled petroleum products, the prices of controlled products are administered by the government. In addition, transportation fuels, MS and HSD, can be marketed by the public sector companies only, i.e. the IOC, the BPCL, the HPCL and the IBP. The government had allowed parallel marketing of LPG and SKO in 1993, under which imports of these products were decanalized and private parties were allowed to import and market them at market-determined prices.

The total consumption of petroleum products in India in 1999/2000 stood at 96.29 MMT. Sales by national oil companies accounted for 94% of the total sales, the rest being marketed by private parties. HSD sales accounted for about 42% of the volume (Figure 2).

The six per cent growth rate in demand for petroleum products over the last decade was arrested in 2000/01. Aggregate PSU (public sector unit) sales for 2000/01 at 90.2 MMT were marginally lower by 0.5% than those in the preceding year. In the retail trade category, only MS witnessed a growth with demand increasing by 12% over the preceding year, while SKO consumption came down by 0.4% and of HSD by 2.7%. The slowdown in demand is attributed to a number of factors ranging from a fall in agricultural demand to a continuing economic slowdown.

---

[1] The technology for bioremediation is being supplied by the Microbial Biotechnology laboratory at TERI, which has developed an efficient bacterial consortium that degrades crude oil and oily sludge efficiently and in a very short time.

[2] ATF has been decontrolled with effect from 1 April 2001

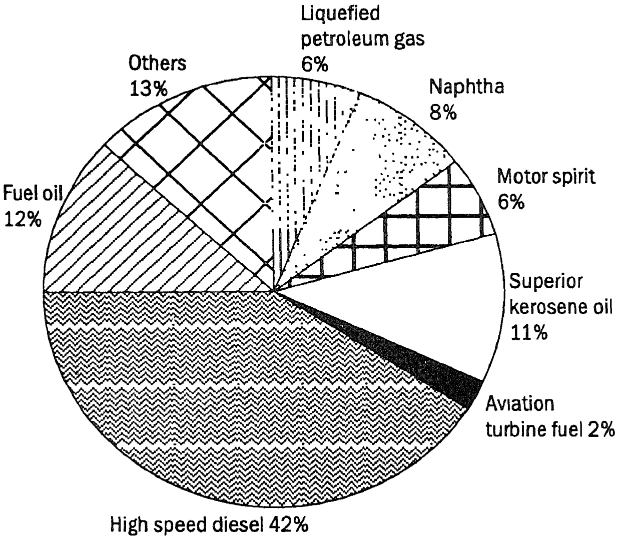


Figure 2 Product-wise sales of petroleum products: 1999/2000
Source MoPNG (2000)

Table IV Existing product pipeline network

Pipeline	*Capacity* (MMTPA)	*Length* (km)
Barauni-Kanpur	1.80	669
Digboi-Tinsukia	0.73	75
Guwahati-Siliguri	0.82	435
Haldia-Barauni	1.25	525
Haldia-Maurigram-Rajbandh	1.35	269
Kandla-Bhatinda	6.00	1443
Koyali-Ahmedabad	1.10	116
Mathura-Jalandhar	3.70	526
Mumbai-Manmad	4 33	252
Mumbai-Pune	3.67	161
Vizag-Vijaywada	4.10	356
Total	28.85	4827

Source Data obtained from the MoPNG

Transport infrastructure

Crude oil

Till recently, the country had only two inland crude oil pipelines: one belonging to the OIL, bringing north-eastern crude oil to Barauni and the north-eastern refineries, and the other belonging to the IOC, taking crude oil from the Gulf of Kachchh to the Koyali and Mathura refineries. There have been extensions to this network. The Haldia–Barauni crude oil pipeline of 4.2 MMTPA capacity was commissioned in February 1999. The IOC also completed augmentation of capacity of Salaya–Viramgram–Koyali crude oil pipeline (Salaya–Viramgram from 17.2 MMTPA to 21.0 MMTPA and Viramgram–Koyali from 5.0 MMTPA to 6.5 MMTPA) in September 1999. The Viramgram–Mathura pipeline has also been extended to carry crude oil to the Panipat refinery (Map 1).

The capacity of the Haldia–Barauni crude oil pipeline is being further expanded from 4.2 MMTPA to 7.5 MMTPA and is expected to be completed by February 2002. New pipelines are expected to be laid from Vadinar to Bina and from Mundra to Bhatinda to cater to the requirements of BPCL's and HPCL's projects.

Petroleum products

Bulk transportation of petroleum products is primarily through rail tank-wagons and pipelines. In 1999/2000, petroleum products moved by rail aggregated 35 MMT while those by pipelines added up to 28 MMT (MoPNG 2000). Details of pipeline capacity are presented in Table IV. The share of petroleum products moved by pipelines has notched up considerably over the past four years while that of rail has declined marginally. The share of the railways is expected to further decline in the future due to budgetary constraints in terms of procuring locomotives and tankwagons, saturation of tracks, gauge conversion, inadequate rolling stocks, etc.

Considering the increasing limitations to move the products by rail and the economics of product movement through pipelines, it is essential to prioritize development of pipeline infrastructure. Other advantages of pipeline transportation over rail transportation include minimum environmental degradation, enhanced safety, multi-product handling, and capacity creation for movement by rail of other products that cannot be moved by pipelines.

Given the need for prioritizing development of pipelines, the PIL (Petronet India Ltd) was formed as a financial holding company to develop petroleum product pipeline infrastructure in the country through its joint venture companies and subsidiaries. The IOC, the HPCL, and the BPCL each have a 16% stake in the venture while the IBP holds 2% stock. The balance 50% has been subscribed to financial institutions and private

Table V Proposed product pipelines by the PIL

Pipeline	*Sponsors*
Kochi-Karur	PIL, BPCL, KRL
Mangalore-Bangalore	PIL, HPCL, MRPL
Chennai-Trichy-Madurai	PIL, IOC, CPCL
Central India Pipeline	PIL, IOC, RPL, Essar Oil
Bina-Jhansi-Kanpur	PIL, BPCL, BORL
Bhatinda-Jalandhar-Jammu	PIL, HPCL, JV refinery
Paradeep-Ranchi-Allahabad	PIL, IOC

PIL - Petronet India Ltd; BPCL - Bharat Petroleum Corporation Ltd; KRL - Kochi Refineries Ltd; HPCL - Hindustan Petroleum Corporation Ltd; MRPL - Mangalore Refineries and Petrochemicals Ltd; IOC - Indian Oil Corporation; CPCL - Chennai Petroleum Corporation Ltd; RPL - Reliance Petroleum Ltd; BORL - Bharat Oman Refineries Ltd

companies. A number of pipelines proposals have been taken up by the company (Table V) (Map 2).

Petronet pipelines have, however, reportedly run into rough weather. The Kochi–Karur pipeline, scheduled for completion by late 2000, is delayed. Work on the Mangalore–Bangalore project was stalled with farmers having apprehensions regarding the pipeline running through their agricultural land. The Central India Pipeline project too has made little progress due to strong opposition from the BPCL and the HPCL. The pipeline will be particularly counterproductive for the BPCL's proposed Bina refinery. Both the IOC and the RPL have a 26% stake in the project while Essar holds 13%.

Port infrastructure

Crude oil and petroleum products are handled at the various ports mentioned in Table VI.

The total cargo handled by Indian ports in 1999/2000 was 272 MMT, of which crude oil and petroleum products accounted for 117 MMT (MoF 2001). The current port infrastructure suffers from severe capacity constraints in terms of draft availability, navigational facilities, jetty availability, etc. In addition, port facilities are inadequate to handle the required volume of coastal traffic, resulting not only in considerable infructuous expenditure on demurrage on coastal and foreign flag vessels but also underutilization of floating capacities besides substantial dead freighting.

Table VI Categorization of ports handling oil

Category	*Ports*
Crude oil	Salaya, Jamnagar, Mumbai, Mangalore, Kochi, Chennai, Vizag, and Haldia
Petroleum products	Kandla, Okha, Mumbai, Goa, Mangalore, Kochi, Tuticorin, Chennai, Vizag, Paradeep, Haldia, and Port Blair

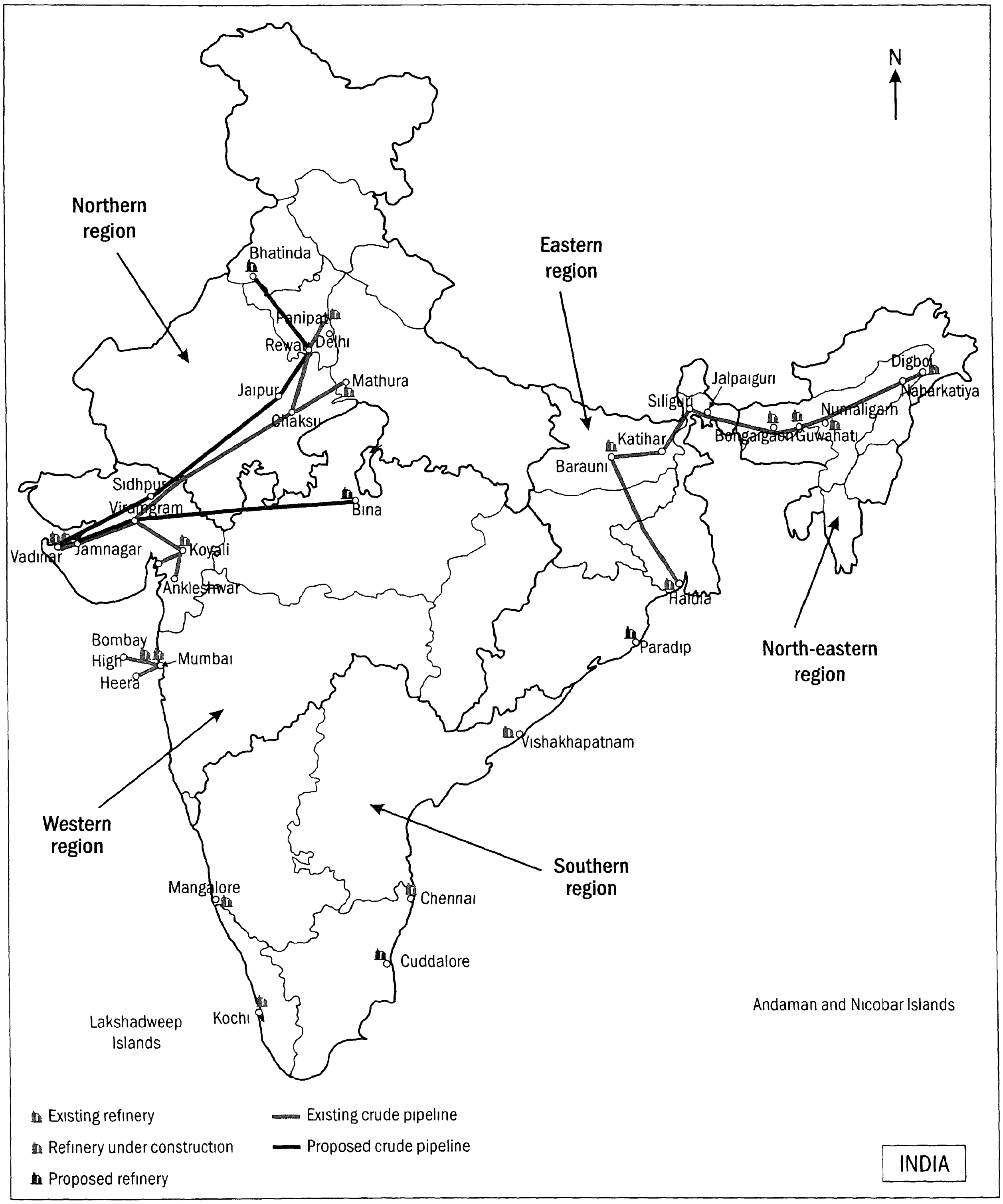
Source MoST (1999)

Pricing

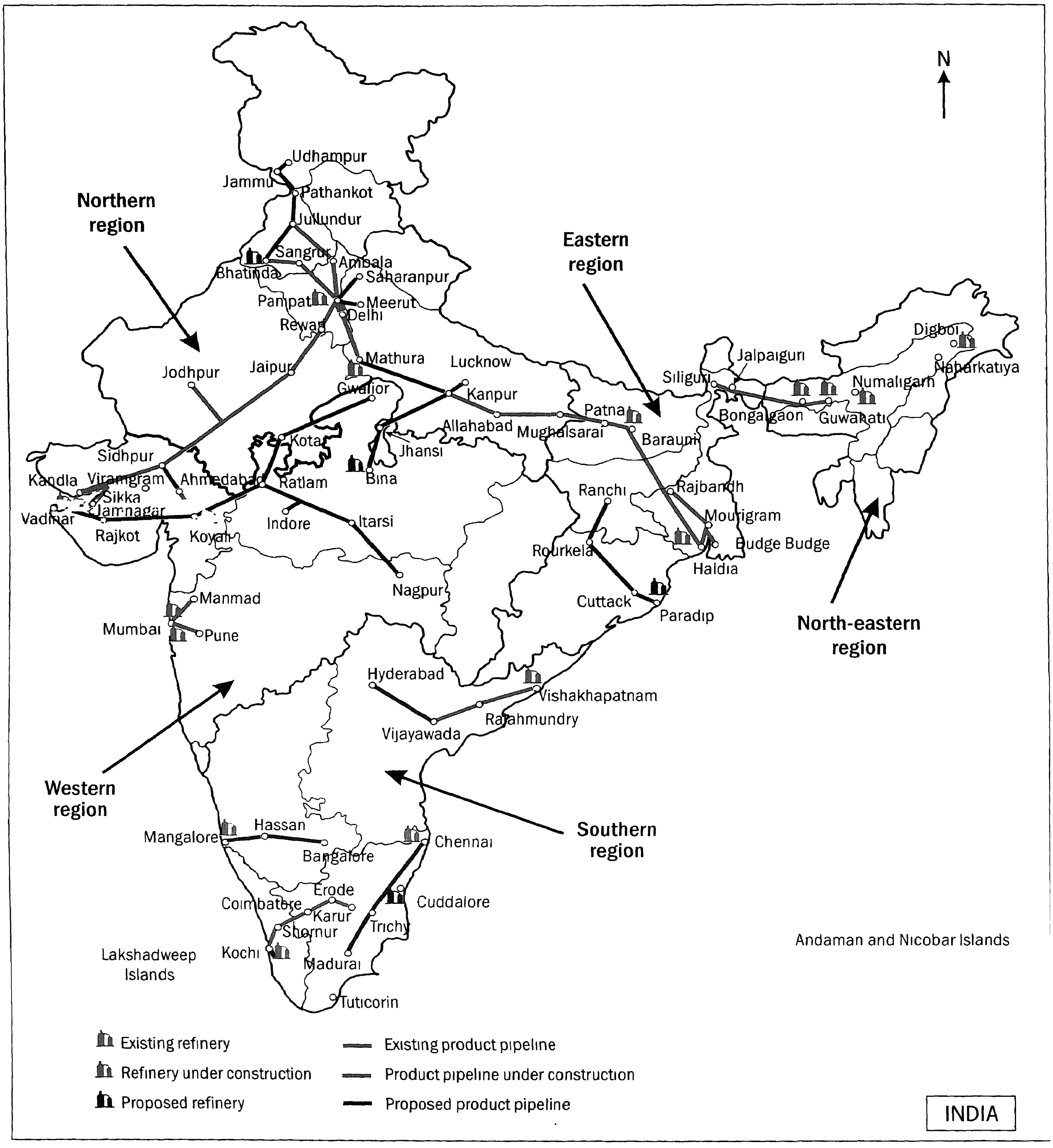
Oil prices in the 1960s were based on the concept of import parity. In the mid-1970s, the OPC (Oil Prices Committee) recommended a complete move away from import parity pricing, mainly on the grounds that the country then had adequate refining capacity and that the structure of West Asian product prices (which was the basis for determining import parity prices) did not reflect the cost pattern and operations of Indian refiners. It recommended the APM (administered pricing mechanism) for the industry, which has been in vogue ever since. The APM essentially constituted a cost-plus pricing regime wherein costs were reimbursed as per standards laid out with respect to throughputs, yield patterns, fuel and loss, operating cost, capital employed, etc. In addition, companies were allowed a 12% post-tax return on their net worth and reimbursed their borrowing costs. Insulating domestic markets from international oil markets required the creation of the Oil Pool Account, an extra budgetary account, which reconciled the interests of the consumers and producers. The APM ensured

- an orderly growth of the oil industry;
- continuous availability of petroleum products to consumers at fairly stable prices;
- continuous availability of crude oil to refiners; and
- achievement of socio-economic objectives of the government.

However, on the flip side, there were serious unintended effects of the APM. Oil pricing has been divorced from underlying economic realities. The prices of politically sensitive products are not reflective of the economic costs of these products. Subsidies and cross-subsidies have resulted in a wide distortion of consumer prices and have led to a wastage of energy. The APM provided little incentive for improving productivity or efficiency



Map 1 Crude pipelines. existing, under construction, and proposed refineries (December 2001)



Map 2 Product pipelines: existing, under construction, and proposed refineries (December 2001)

as returns were guaranteed on the capital employed. Competition was stifled with marketing companies acting as mere distribution companies.

Meanwhile, over the 1980s and 1990s, import of petroleum products soared 10-fold from over 2.2 million tonnes in 1975 to nearly 18 million tonnes in 1995. Given the high levels of import in the Indian economy, the APM, which insulated the country from global markets, seemed meaningless. Further, it was estimated that during the Ninth Plan period, an investment of about 1240 billion rupees would be required to create the necessary infrastructure to meet the demand of petroleum products in the country. It was recognized that such a scale of investment was not possible by the government or the public sector oil companies. Participation of private capital from both domestic and international sources was considered imperative. The APM, divorced from economic realities, was considered far from attractive for inviting private capital.

Accordingly, in 1995, the MoPNG set up the Oil Industry Restructuring Group ('R' Group) to put forth a time-bound programme for reforms in the petroleum sector. As a follow-up of the R Group recommendations, the government had appointed an ETG (Expert Technical Group), an inter-ministerial committee, which was required to examine various scenarios reflecting the impact of different levels of duty structures on various sectors.

The ETG recommended a time-bound programme of reforms to move towards a market-driven pricing mechanism for petroleum products in the country. The impacts of the ETG recommendations are listed below.

- The cost-plus formula for pricing of indigenous crude oil was withdrawn by linking the price receivable to oil producers to a phased import parity scheme.
- Retention pricing system for the refineries was abolished and refinery gate prices were linked to import parity except for controlled products, namely MS, HSD, SKO, LPG, and ATF. Refinery gate prices for controlled products were fixed on an adjusted import parity basis.
- Ex-storage point prices of HSD were fixed at adjusted import parity with immediate effect, while consumer prices of other controlled products were linked to a phased import parity. Prices of other petroleum products were decontrolled.
- Imports and exports of all petroleum products except crude oil, NGLs (natural gas liquids), ATF, MS, and HSD were decanalized. Sourcing and imports of crude oil by private and joint sector refineries were allowed.
- Phased rationalization of duties on crude oil and petroleum products was announced.
- Conditional marketing rights for transportation fuels (MS, HSD, and ATF) subject to investments of 20 billion rupees in refining or a minimum crude oil production of 3 million tonnes per annum were announced.
- Establishment of a regulatory framework to oversee the functioning of and enforcing a competitive framework in the hydrocarbons sector was suggested.

In addition, the refining sector was delicensed in 1998. Further, while naphtha exports were decanalized with effect from June 1998, FO (furnace oil) imports were decanalized under the provisions of the export–import policy in July 1998. Freight under-recoveries on HSD to the extent of 20% were passed on in the selling prices in January 1999. Despite ETG's recommendations, diesel prices continue to be administered. Diesel subsidy for 2000/01 is reportedly estimated at 91 300 million rupees, constituting almost 40% of the total subsidy on petroleum products.

On a more positive note, the recent decontrol of ATF prices leaves only four products in the ambit of the APM. Full deregulation of the petroleum sector is expected by April 2002.

Oil prices

The Dubai benchmark crude oil remained above $22/bl (barrel) throughout 2000/01, though the marker displayed substantial volatility in the last quarter of 2000 (Figure 3). Responding to mounting international pressure, OPEC (Organization of Petroleum Exporting Countries) announced an increase in production of 800 000 barrels a day effective from 1 October 2000. By 31 October 2000, an additional 500 000 barrels a day was released into the world oil markets.

While prices dipped marginally in November, they plummeted to $23/bl in December on reports of strong US inventories and expectations of Iraqi oil flows. OPEC reacted swiftly and announced production cuts of 1.5 million barrels a

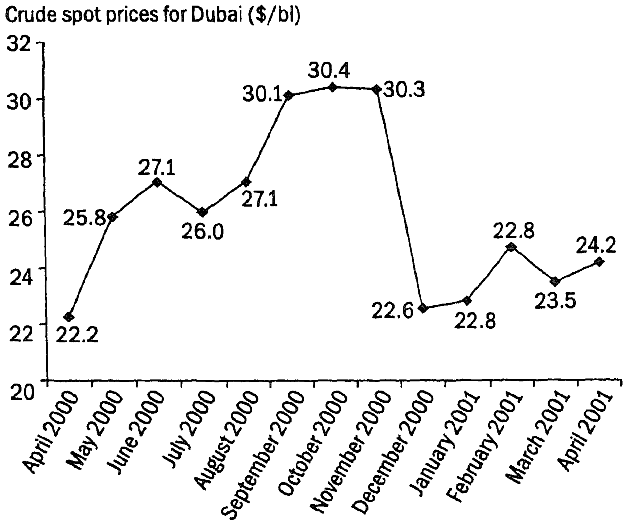


Figure 3 Monthly average spot quotations for Dubai crude oil ($/bl)
Source Petroleum Argus Ltd (2000, 2001)

day in January 2001. Oil prices started creeping northwards and drew further support from an additional 1 million barrels a day cut in March 2001.

The country's oil import bill rose in tandem, from 540 billion rupees (12 billion dollars) in 1999/2000 to about 800 billion rupees in 2000/01. Spiralling oil prices have also pushed up the deficit in the oil pool account. The year 2000/01 ended with an estimated deficit of 120 billion rupees (3 billion dollars) in the oil pool. If prices remain at around $25/bl, the deficit in the pool by the end of 2001/02 is likely to be 190 billion rupees (4.75 billion dollars).

Tariffs

In the wake of spiralling oil prices, the government revised the customs duty on crude oil and transportation fuels in September 2000. The duty on crude oil was brought down from 15% to 10% and that on transportation fuels from 25% to 20%. The move helped to check the growing deficit in the Oil Pool Account. There were no further changes in customs duties on crude oil or transportation fuels in the budget for the current fiscal.

However, a five per cent duty has been introduced for SKO sales under the PDS. While the introduction of this duty did not impact retail prices, it contributed towards an increase in the deficit in the oil pool with no change in the ex-storage point prices. On the other hand, the introduction of duty on SKO led to a marginal improvement in refinery margins, as the import parity price payable to refineries became marginally higher.

The adjustments carried out in September 2000 included reduction in excise duty on HSD from 16% to 12% and exemption of special excise duty of 16% on MS. These were brought back to their previous levels with the budget. However, the burden of the increase was not passed on to the consumers, which led to a marginal adverse impact on the liquidity of marketing companies, as their receivables from the pool became higher.

Gas demand

Gas production in the country stood at 28.4 BCM (billion cubic metres) in 1999/2000. The three main producing basins in the country – the Western offshore region, the Cambay basin in Gujarat, and Upper Assam region – are in the mature phase of exploration. As per the projections of the Sub-group on Utilization of Natural Gas constituted under the Hydrocarbon Vision 2025, the domestic gas availability is expected to decline to about 16 BCM by 2011/12.

On the other hand, the demand for natural gas in the country has been growing rapidly. Gas sales in the country increased at an annual rate of 7.2% over the last decade. The demand for gas accrues from the preference for gas use in power generation and fertilizer production. Gas sales[3] in 1999/2000 aggregated 23.8 BCM. The sectoral shares are presented in Figure 4.

With domestic gas production expected to decline in the future, rising gas demand in the country will have to be met largely from imported gas.

Options for gas imports

Pipelines

India is considering importing gas through pipelines on both the eastern and the western coasts. On the west coast, gas imports are being envisaged from the South Pars field in Iran, through Pakistan. The Indian government has held several rounds of negotiations with the National Iranian Oil Company. Both offshore and onshore routes are under consideration, though both Iran and Pakistan are in favour of the latter, as the offshore

---

[3] Production net of flaring and offtakes by the ONGC

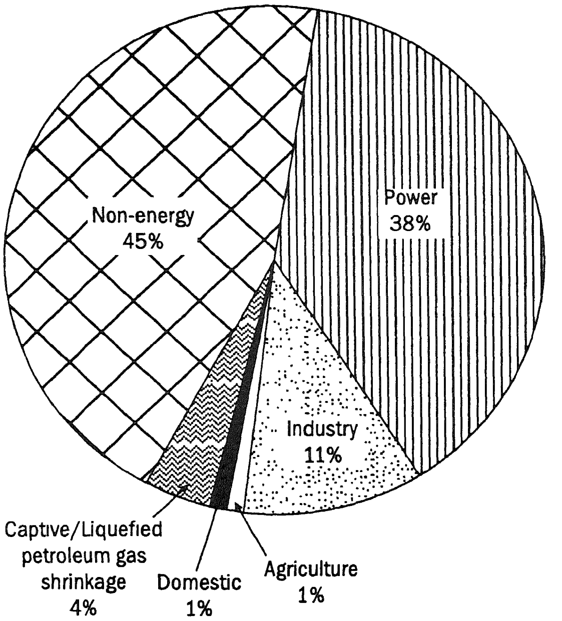


Figure 4 Industry wise offtake of natural gas: 1999/2000
Source MoPNG (2000)

option could be considerably more expensive than the 4.5 billion dollars onshore route.

The Indian government has had reservations about the onland route based on perceptions of problems connected with security of supplies. However, the Indian stand appears to be more open now. Accordingly, feasibility studies have been initiated for both the onshore and offshore routes. The NIOC (National Iranian Oil Company) has engaged Australia's BHP to conduct a feasibility study for the onshore route, while the feasibility of the offshore route is to be analysed by Snamprogetti of Italy.

On the East coast, Unocal has proposed a pipeline from the Bibiyana gas field in Bangladesh to India. With 187 BCM of gas reserves in place, the field has a peak production capacity of 38 million m^3/day. Unocal has proposed a route from Rashidpur in Bangladesh to hook up with the HBJ (Hazira–Bijapur–Jagdishpur) pipeline system in India after crossing the states of West Bengal, Bihar, and Uttar Pradesh. The 1350-km, 30-inch pipeline is expected to have an average flow rate of 14 million m^3/day.

The Bangladesh government, however, has had some reservations regarding the sufficiency of gas reserves in Bangladesh. While proven gas reserves in Bangladesh are 311 BCM, the US Geological Survey has estimated that undiscovered gas reserves in Bangladesh could be as much as 949 BCM (EIA 2001). However, with uncertainty regarding firm assessments on reserves and future demand, political parties are reluctant to commit to gas exports. Decisive action on the issue is only expected after the next general elections in the country.

Liquefied natural gas

With slow progress on the pipelines front, LNG has received substantial attention as the alternative to pipeline imports. A number of LNG projects have been proposed in the country (Map 3), both along the east and the west coasts. However, with the recent experience with Enron, the viability of LNG for power generation is being questioned.

The US-based Enron was the first company in India to come up with a proposal for the setting up of an LNG terminal. The LNG project was envisaged under the 2450 MW Dabhol Power Project. Phase I (740 MW) of the project had been commenced on liquid fuel and the company had achieved financial closure for Phase II (1624 MW), which included the 5-MMTPA LNG terminal. Power from the naphtha-based plant was being drawn by the MSEB (Maharashtra State Electricity Board).

However, reduced requirements by the MSEB combined with a high run of naphtha prices, resulted in prohibitively high costs for power drawn from the DPC (Dabhol Power Company). The MSEB subsequently expressed its inability to draw power from DPC's power units in Phase II as well, scheduled to commence operations shortly. Eventually, serious differences arose between Enron and the MSEB with respect to compliance with the agreement between them. The MSEB backed by the Maharashtra state and the Indian government wished to renegotiate the existing PPA (power purchase agreement) based on the recommendations of the Godbole Committee formed by the Maharashtra government to examine various issues. Meanwhile, in May 2001, the DPC issued a pre-termination notice to the MSEB. Thereafter, the Godbole Committee, on behalf of the state government, invited the DPC for negotiations.

Prospects for a settlement to the dispute remain bleak. The DPC had moved in favour of activating the escrow account facility and initiating arbitration proceedings against the MSEB; however, the MERC (Maharashtra Electricity Regulatory Commission) restrained the DPC from doing so. The matter is now being taken up by the Supreme Court.

Other prominent projects envisaging LNG imports include the following ones.

The TEC (Tata Electric Company) and the TGP (Total Gas & Power India) are setting up a 3-MMTPA LNG terminal at Trombay, Maharashtra. The TEC's thermal plants at Trombay are expected to switch over to LNG by 2003 to coincide with Phase I of the project for 1.3 MMTPA of LNG. The two companies have also formed a joint venture with GAIL, INDIGAS (Indian Natural Gas Company) for marketing the gas during Phase II.

Petronet-LNG, promoted by GAIL, the ONGC, the IOC, the BPCL and the NTPC, is putting up a 5-MMTPA LNG terminal at Dahej, Gujarat, and a 2.5-MMTPA terminal at Kochi, Kerala. The company has signed an agreement with Qatar's Rasgas for the supply of 5 MMTPA of LNG from mid-2003 and 2.5 MMTPA by 2005.

The Dakshin Bharat Energy Consortium, a joint venture of Unocal, Siemens, Grasim, CMS, and Woodside, has proposed a 2.5 MMTPA LNG terminal at Ennore, Tamil Nadu. The proposal, to be developed in collaboration with TIDCO (Tamil Nadu Industrial Development Corporation), includes a 1850-MW power plant.

British Gas and Sea King Infrastructure are putting up a 5-MMTPA LNG terminal at Pipavav, Gujarat. In 1999, the joint venture company – Gujarat Pipavav LNG Ltd – signed an MoU (memorandum of understanding) with the NTPC, granting it 26% stake in the project. However, the equity structure is yet to be finalized. LNG from the proposed terminal will be used at the NTPC's Kawas and Gandhar power projects. The NTPC's total requirement for these projects is expected to be about 1.5 MMTPA.

The Orissa government has signed an agreement with Al-Manhal International Group to set up an LNG complex consisting of an LNG regasification terminal of 5 MMTPA, a petrochemical complex, a urea–ammonia fertilizer complex of 1.2 MMTPA and a 2500–3000 MW power plant. The Gopalpur LNG project will source gas from ALNG (Australia Liquefied Natural Gas), which has committed to supply 5 million tonnes of liquefied gas annually for 20 years.

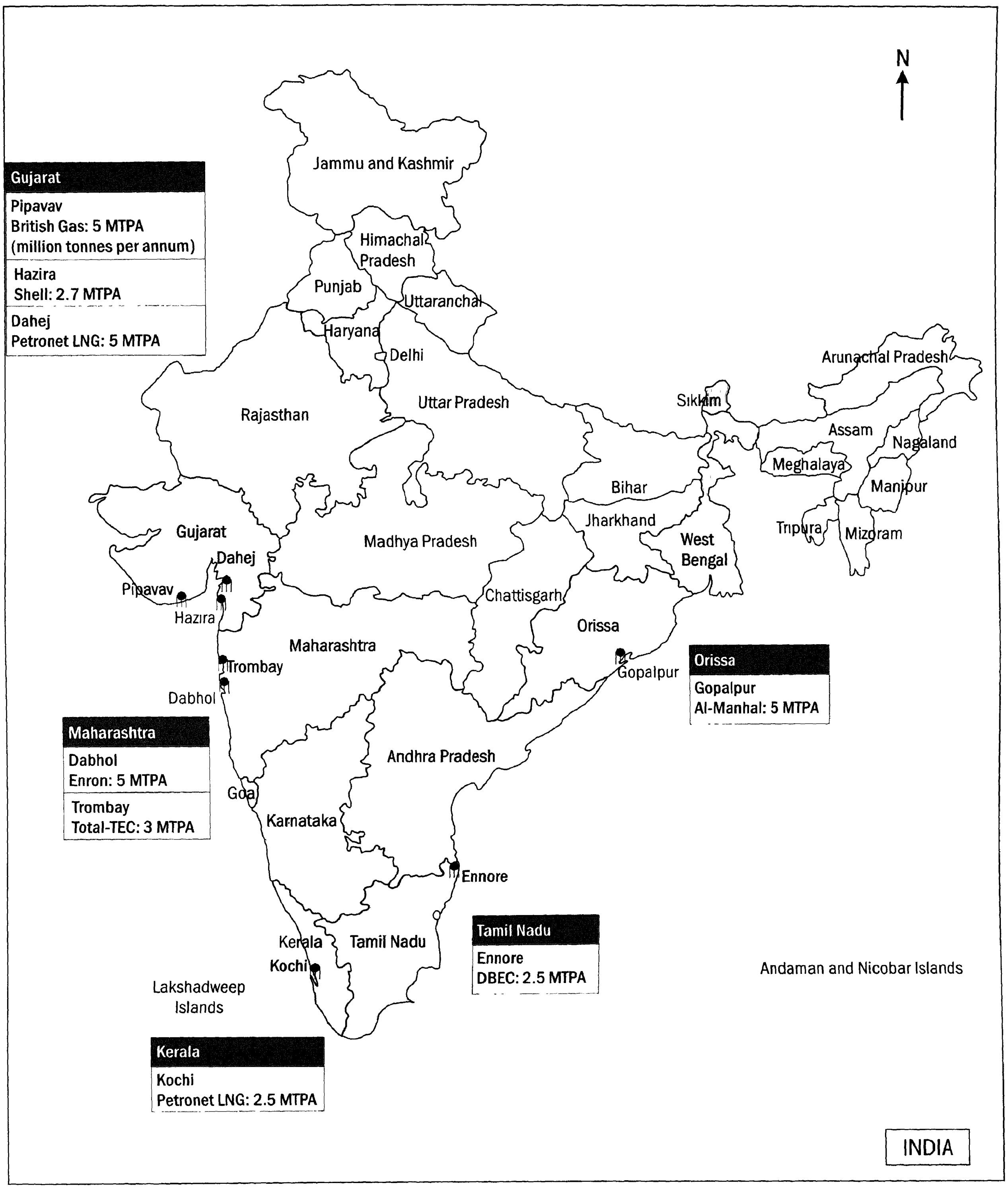
The Reliance Industries has entered into an MoU with the National Iranian Oil Company and BP to set up an 8-MMTPA liquefaction facility in Iran. Gas for the project will be sourced from Iran's offshore South Pars Field-Phase II, while the liquefaction facility will be set up at Assaluyeh on the Persian Gulf. A joint venture company is under formation to develop on the above liquefaction and export facility. Reliance is expected to get marketing rights for 5–6 MMTPA of LNG. The consortium has undertaken a detailed feasibility study for the proposed project. Reliance is considering setting up a 5 MMTPA regasification terminal at Jamnagar, Gujarat, for the same.

The Royal Dutch Shell group has floated two fully owned companies for the development of the port and an LNG terminal at Hazira, Gujarat. The Hazira Port Private Ltd will provide all the facilities for a multi-cargo port at Hazira, including development of a suitable approach channel and reclamation of land from the sea. The Hazira LNG Private Ltd company intends to set up a 5-MMTPA regasification terminal. Gas for the project is expected to be sourced from Shell's existing liquefaction facilities with spare capacity. Unlike other projects being developed through the project financing route, Shell is taking up the development costs for the project on its own balance sheet.

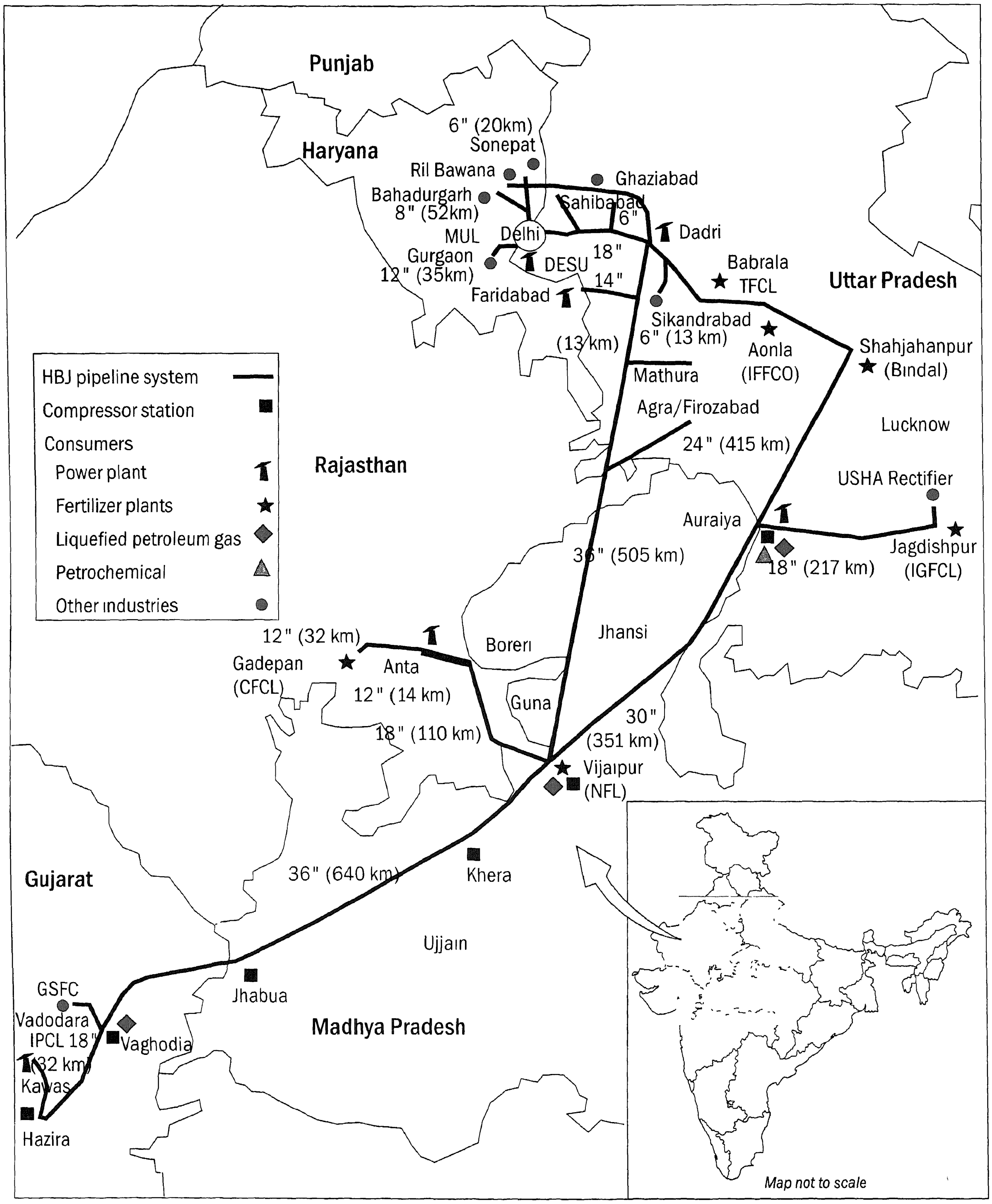
In July 2000, the IOC-led consortium announced an LNG terminal at Kakinada, Andhra Pradesh, to cater to the gas-based power projects and other industries in the region. The KIOLC (Kakinada Indian Oil LNG Consortium), with Petronas (Malaysia) and Cocanada Port Company (P) Ltd as partners, has received a letter of support from the Andhra Pradesh government to set up the LNG terminal. In the first phase, the KIOLC will import 2.5 MMTPA of LNG. The conceptual scheme provides for the stepping up of LNG imports to 10 MMTPA in phases.

Gas transmission

The existing gas infrastructure supports production and transportation of about 90 million m^3/day, and transmission and distribution of about 65–70 million m^3/day. The western offshore region is the major source of gas, accounting for more than 70% of the total gas production. Adequate offshore facilities exist for the compression and evacuation of gas to shore-based facilities at Uran in Maharashtra and Hazira in Gujarat. Shore-based facilities in Uran receive gas from two



Map 3 Prominent LNG (liquefied natural gas) terminals (December 2001)



Map 4 HBJ (Hazira–Bijapur–Jagdishpur) transmission system

Facing page no 77

offshore trunk gas pipelines, namely Bombay High to Uran and Heera Field to Uran; similarly, shore-based facilities at Hazira receive gas from two offshore trunk gas pipelines from the South Bassein field.

As regards the gas transmission and distribution network, a system of about 3800-km long pipeline trunk as well as spur (consumer) lines is presently in position. The largest pipeline system is the 2300-km long HBJ trunk pipeline system (Map 4). The capacity of the HBJ system was expanded from 18.3 million m^3/day to 33.4 million m^3/day in July 1998. A trunk section (90 cm in diameter) has been added between Bijapur and Dadri. In addition, there are regional gas grids of varying sizes in Gujarat (Cambay Basin), Andhra Pradesh (Krishna–Godavari Basin), Assam (Assam–Arakan Basin), Maharashtra (Ex-Uran terminal), Rajasthan (Jaisalmer Basin), Tamil Nadu (Cauvery Basin), and Tripura (Arakan Basin).

To facilitate distribution of LNG from the Dahej terminal, GAIL is planning to enhance the capacity of the HBJ pipeline from 34 to 60 million m^3/day. GAIL is also planning to add new pipelines in the Krishna–Godavari and Cauvery basins.

Gas prices

In 1997, the government linked the landfall price of gas to a basket of FOs. The government also worked out a schedule for raising gas prices to FO import parity. While the prices in 1997/98 were fixed at 55% of the import parity price, in 1999/2000 these were increased to 75% of the import parity price. At the same time, a concessional price of 45% of the import parity price was charged in the north-eastern states.

On account of the linkage to FO prices, with the rise in global oil prices, gas prices at the landfall point hit the ceiling of Rs 2850/1000 m^3 in October 1999. The concessional price for gas-based industries in the North-east also rose to Rs 1700/1000 m^3. Gas prices pertain to a calorific value of 10 000 kcal/1000 m^3. However, since the gas transported by GAIL has a calorific value of 9000 kcal/1000 m^3, consumers in effect pay 10% less. The consumer price along the HBJ pipeline was fixed at Rs 4000/1000 m^3, which included a flat transportation charge of Rs 1150/1000 m^3. The delivered price is built up after adding royalty, taxes, and other statutory levies on the consumer price.

The Gas Pricing Committee had recommended that natural gas prices be increased gradually so that they are at par with the import prices of LNG by 2002. The Union Cabinet endorsed the decision and a phased linkage of domestic gas prices to a basket of FOs was implemented in 1997. The pricing system was to be reviewed in April 2000. The MoPNG, however, has put off the decision on the revision of natural gas prices.

Regulatory framework

Legislation

The legal framework for the regulation of exploration and production of oil and gas is provided by the Oilfields Development and Regulation Act, 1948, and the Petroleum and Natural Gas Rules, 1959. The downstream hydrocarbons sector is regulated by the Petroleum Act, 1934, and various control orders under the Essential Commodities Act, 1955. A brief summary of the key provisions of the existing legal framework is given here.

The Petroleum Act, 1934

The Act empowers the central government to make rules for import, transport, and storage of petroleum. It also empowers the central government to regulate the production, refining, and blending of petroleum.

The Oilfields (Regulation and Development) Act, 1948

The Act provides for the regulation of oilfields and for the development of mineral oil resources. It empowers the central government to make rules with respect to mining leases and for the use of equipment, regulation of operations, and methods of production in the development of mineral oil resources.

The Petroleum and Natural Gas Rules, 1959

The Rules cover the grant of exploration licences and mining leases and regulations relating to conservation and development of oil and natural gas resources.

The Essential Commodities Act, 1955

The Act authorizes the central government to regulate production, supply, distribution, and trade of essential commodities, to ensure their availability at fair prices. Under this Act, petroleum and petroleum products are covered under the definition of essential commodities. The Act empowers the central government to make orders that may provide for regulating by licences or otherwise production, transport, distribution, disposal, acquisition, use, or consumption of any essential commodity. In addition, the central government may control the price at which any essential commodity is bought or sold.

Current regulatory structures

The DGH (Directorate General of Hydrocarbons) was set up under the administrative control of the MoPNG in 1993 to promote sound management of the Indian petroleum and gas resources. The DGH acts as a regulator for reservoir management of oil and gas fields; monitors PSCs on behalf of the Government of India; and acts as a project facilitator, assisting companies to get clearances/approvals from various ministries.

On the downstream side, the OCC (Oil Coordination Committee) acts as a *de facto* regulator for the oil industry. The OCC was established in 1975 to implement the elaborate pool accounts mechanism recommended by the Oil Prices Committee. As the nodal agency for the sector, key functions of the OCC include

- administration of pool accounts
- coordination of the transportation of crude oil imports for PSU refineries
- inland distribution of petroleum products
- deciding on allocation of crude oil and product pattern of refineries based on imports, exports and national/regional demands, logistics of transportation, and other allied matters.

Thus, the OCC under the administrative control of the MoPNG, currently performs the functions of a planner, coordinator, advisor, and regulator in the downstream sector.

Proposed regulatory framework

With the APM scheduled to be dismantled by April 2002, there is need for a statutory regulator to handle downstream regulatory issues. Reportedly, the government is actively considering the establishment of a regulatory authority for the petroleum sector on the lines of TRAI (Telecom Regulatory Authority of India). The regulator will decide on several issues, including those related to marketing rights for private players like Reliance Petroleum and Essar.

Meanwhile, the union government has reportedly decided to constitute a separate regulatory authority for the upstream hydrocarbons sector. A draft framework for the same is currently being considered by the MoPNG. The UHRA (Upstream Hydrocarbon Regulatory Authority) is expected to enjoy full operational and functional autonomy, though its funding will be through the Oil Industry Development Board. The draft suggests that it should be a multi-member body with a full-time chairman and members. The government may also consider a coordination committee for sorting out matters among the UHRA, the union government, and state governments.

References

EIA (Energy Information Administration). 2001
Country analysis briefs: Bangladesh
United States Energy Information Administration, Department of Energy, USA, Washington, DC
http://www.eia.doe.gov/emeu/cabs/bangla.html

MoF (Ministry of Finance). 2001
Economic Survey 2000–2001
New Delhi: Economic Division, MoF, Government of India

MoPNG (Ministry of Petroleum and Natural Gas). 2000
Indian Petroleum and Natural Gas Statistics, 1999–2000
New Delhi: MoPNG, Government of India

MoPNG (Ministry of Petroleum and Natural Gas). 2001a
New Exploration and Licensing Policy-II
http://www.india-nelp2.com/content/content.html

MoPNG (Ministry of Petroleum and Natural Gas). 2001b
Annual report: 2000–2001
New Delhi: MoPNG, Government of India

MoPNG (Ministry of Petroleum and Natural Gas)
Basic Statistics *(various issues)*
New Delhi: MoPNG, Government of India

MoST (Ministry of Surface Transport). 1999
Basic Port Statistics 1998/99
New Delhi: MoST, Government of India

Petroleum Argus Ltd. 2000, 2001
Argus global markets (various issues)
London: Petroleum Argus Ltd.

Table 1.35 Proven and balance recoverable reserves of crude oil (**million tonnes**) and natural gas (**billion cubic metres**) by state: 1990 to 2000

Crude oil and natural gas	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Crude oil											
Onshore											
Gujarat	161.7	158.3	156.6	155.1	153.4	154.6	154.3	151.7	150.2	146.4	145.3
Assam	145.0	156.2[a]	160.8[a]	158.2[a]	156.1[a]	150.0	146.3	150.7	154.1	154.1	156.1
Total	306.7	314.5	317.4	313.3	309.5	304.6	300.6	302.4	304.3	300.5	301.4
Offshore											
Bombay High	432.1	491.7	483.7[b]	465.8[b]	455.2[b]	414.3[b]	419.9	436.1	404.2	339.0	322.4
Total (crude oil)	738.8	806.2	801.1	779.1	764.7	731.7	728.7	747.1	716.37	660.3	644.8
Natural gas											
Onshore											
Gujarat	93.6	93.4	94.0	92.9	92.1	94.0	91.1	89.1	88.7	84.4	82.5
Assam	135.5[c]	151.7[c]	160.5[c]	156.1[c]	156.2[c]	125.6[c]	131.4	133.8	137.9	142.2	148.5
Rajasthan	1.0	1.2	1.3	3.8	3.8	4.1	4.5	4.5	4.4	–	–
Total	229.1	246.3	255.7	252.8	252.1	223.7	227.0	227.4	231.0	226.6	231.0
Offshore											
Bombay High	457.4	483.5	479.8[d]	465.1[d]	454.6[d]	414.7[d]	374.2	388.1	362.0	363.7	351.6
Total (natural gas)	686.5	729.8	735.6	717.9	706.7	676.1	641.3	692.1	674.8	648.0	647.5

[a] includes crude oil onshore reserves in Nagaland, Andhra Pradesh, and Tamil Nadu

[b] includes crude oil offshore reserves in Andhra Pradesh and Tamil Nadu

[c] includes natural gas onshore reserves in Andhra Pradesh, Arunachal Pradesh, Tamil Nadu, Tripura, and Nagaland

[d] includes natural gas offshore reserves in Andhra Pradesh, Andaman and Nicobar Islands, Gujarat, and Tamil Nadu

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 1999. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (exploration, reserves, and production)]

Table 1.36 Exploratory and developmental drilling by the Oil and Natural Gas Corporation Ltd and the Oil India Ltd: 1990/91 to 1999/2000

Drilling (wells and metreage)	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]
Exploratory wells										
Onshore	176	176	172	147	166	177	171	114	110	123
Offshore	73	61	69	33	48	27	28	20	25	28
Total	249	237	241	180	214	204	199	134	135	151
Metreage (km)										
Onshore	434	454	413	374	445	427	407	297	273	337
Offshore	184	167	176	96	116	77	80	50	60	87
Total	618	621	589	470	561	504	487	347	333	424
Developmental wells										
Onshore	220	193	196	205	191	171	156	135	124	121
Offshore	66	22	31	129	41	52	18	38	34	35
Total	286	215	227	334	232	223	174	173	158	156
Metreage (km)										
Onshore	455	401	441	509	475	384	355	326	267	275
Offshore	92	41	75	264	88	86	48	82	85	59
Total	547	442	516	773	563	470	403	408	352	334

[a] provisional

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (exploration, reserves, and production)]

Table 1.37 Production (thousand tonnes) of crude oil: 1985/86 to April-December 2000

State	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000*[b]
Crude oil production[a]												
Onshore												
Gujarat	4 319	6 398	6 035	5 807	5 076	6 279	6 362	6 158	5 951	5 828	5 665	351
Assam / Nagaland	4 966	5 076	4 899	4 986	5 090	5 043	5 044	4 796	5 114	5 078	4 975	3 928
Arunachal Pradesh	60	43	42	59	49	35	28	36	27	38	44	24
Tamil Nadu / Andhra Pradesh	–	313	318	352	536	656	418	382	390	450	523	497
Total	9 345	11 830	11 383	11 204	11 651	12 013	11 852	11 372	11 482	11 395	11 204	8 800
of which												
Oil India Ltd	2 654	2 649	2 529	2 523	2 811	2 883	2 882	2 870	3 094	3 294	3 283	2 466
ONGC (Oil and Natural Gas Corporation Ltd)	6 691	9 181	8 854	8 681	8 840	9 130	8 970	8 502	8 388	8 104	7 921	6 334
Offshore												
ONGC	10 712	21 191	18 963	15 746	15 375	20 226	22 665	20 183	19 863	18 286	16 727	12 638
Private/Joint venture company	–	–	–	–	–	–	650	1 346	2 514	3 042	4 018	3 087
Grand total	30 168	33 021	30 346	26 950	27 026	32 239	35 167	32 901	33 859	32 723	31 949	24 525

[a] includes condensates

[b] April-December 2000

Sources

1 MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas.*** New Delhi: Ministry of Petroleum and Natural Gas.

2 MoPNG. 2001. ***Annual Report 2000/01.*** New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.38 Production (**million cubic metres**) of natural gas: 1990/91 to 2000

State	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000*^{b}
Natural gas production											
Onshore											
Gujarat	1 696	1 698	1 946	2 166	2 462	2 878	2 932	3 115	3 166	3 096	2 181
Assam / Nagaland	2 011	31	52	47	1 909	1 880	1 941	2 018	2 055	2 083	1 672
Arunachal Pradesh	29	271^a	676^a	788^a	37	32	23	24	24	23	18
Tripura	70	–	–	–	97	131	154	196	307	353	266
Tamil Nadu	64	–	–	–	98	117	92	95	107	138	137
Andhra Pradesh	46	–	–	–	640	679	799	1 022	1 218	1 363	1 173
Rajasthan	–	–	–	–	–	12	10	148	163	151	116
Total	3 916	4 251	4 708	4 979	5 243	5 729	5 951	6 618	7 040	7 207	5 563
of which											
Oil India Ltd	1 518	–	–	–	1 435	1 433	1 467	1 670	1 713	1 729	1 413
ONGC (Oil and Natural Gas Corporation Ltd)	2 398	–	–	–	3 808	4 296	4 484	4 948	5 237	5 478	4 150
Offshore											
ONGC	14 082	14 394	13 352	13 356	14 138	16 579	16 794	18 102	17 514	17 774	13 949
Private/Joint venture company	–	–	–	–	–	331	510	1 681	2 874	3 465	2 634
Grand total	17 998	18 645	18 060	18 335	19 381	22 639	23 255	26 401	27 428	28 446	22 146

[a] includes Andhra Pradesh, Tamil Nadu, and Tripura

[b] April-December 2000

Sources

1 MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas.*** New Delhi: Ministry of Petroleum and Natural Gas.

2 MoPNG. 2001. ***Annual Report 2000/01.*** New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.39 Reserve replacement ratio and life of reserves for crude oil (**million tonnes**) and natural gas (**billion cubic metres**): 1990 to 1999/2000

	Crude oil						*Natural gas*					
Year	*Recoverable reserves*	*Net addition/ depletion*	*Production*	*Gross addition to recoverable reserves*	*Reserves replacement ratio*[a]	*Life of reserves (years of current production)*	*Recoverable reserves*	*Net addition/ depletion*	*Production*	*Gross addition to recoverable reserves*	*Reserves replacement ratio*[a]	*Life of reserves (years of current production)*
1990	806	67	33.3	100.3	3.0	24.2	730	46	18.0	64.6	3.50	39.3
1991	801	−5	31.0	26.0	0.8	25.8	736	6	18.7	24.7	1.30	39.4
1992/93	779	−22	27.0	5.0	6.2	28.9	718	−18	18.1	−1.01	–	39.7
1993/94	765	−14	27.0	13.0	0.5	28.3	707	−11	18.3	7.3	0.40	38.6
1994/95	732	−33	32.2	0.8	0.02	22.7	660	−47	19.4	−27.6	−1.4	34.0
1995/96	727	−5	35.2	30.2	0.86	20.7	640	−20	22.6	2.6	0.12	28.7
1996/97	747	20	32.9	52.9	1.61	–	692	52	23.3	75.3	3.23	–
1997/98	716	−31	33.9	2.9	0.09	–	675	−17	26.4	9.4	0.36	–
1998/99	658	−58	32.7	−25.3	−0.77	–	628	−47	27.4	−19.6	0.04	–
1999/2000	645	−13	32.0	19.0	0.59	–	647	19	28.4	9.4	0.33	–

[a] defined as a ratio of gross addition of reserves to total production during the year

Note

The oil and natural gas reserves data are taken at the end of each calendar/financial year and production during the year for the purpose of calculation.

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (exploration, reserves, and production)]

Table 1.40 Installed capacity (**thousand tonnes**) and refinery crude throughput: 1990/91 to 1999/2000

	Installed capacity	*Refinery crude throughput*						
Refining company	*(1 April 2000)*	*1990/91*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000*[a]
Public sector	85 540	51 772	58 702	59 958	61 313	64 469	74 052	57 554
IOC (Indian Oil Corporation) Ltd, Guwahati	1 000	783	839	848	856	836	914	483
IOC Ltd,Barauni	4 200	2 416	2 322	1 895	2 181	2 204	3 411	2 313
IOC Ltd, Gujarat	12 500	9 334	10 167	10 352	10 694	10 935	11 109	9 183
IOC Ltd, Haldia	3 750	2 835	3 416	3 451	4 706	4 714	4 105	2 824
IOC Ltd, Mathura	7 500	7 808	8 332	8 113	8 565	8 909	8 125	5 129
IOC Ltd, Digboi	650	566	559	477	502	553	603	520
IOC Ltd, Panipat	6 000	–	–	–	–	2 208	4 153	4 292
Bharat Petroleum Corporation Ltd, Mumbai	6 900	6 957	7 460	7 590	7 940	8 878	8 907	6 321
HPCL (Hindustan Petroleum Corporation Ltd), Mumbai	5 500	5 766	5 965	6 534	6 378	5 203	6 007	4 184
HPCL, Visakhapatnam	7 500	3 464	5 037	4 847	2 467	3 861	4 555	4 841
Kochi Refineries Ltd, Kochi	7 500	5 006	7 421	7 293	7 729	7 770	7 830	5 615
CPCL (Chennai Petroleum Corporation Ltd), Chennai	6 500	5 698	5 599	6 621	6 965	6 101	6 377	4 537
CPCL, Narimanam	500	–	370	345	556	644	636	430
Bongaigaon Refinery and Petrochemicals Ltd	2 350	1 139	1 215	1 542	1 718	1 653	1 905	1 170
Private sector/Joint venture corporation	36 690	–	39	2 912	3 853	4 069	11 912	19 376
Mangalore Refinery and Petrochemicals Ltd	9 690	–	39	2 912	3 853	4 069	5 200	4 847
Reliance Petroleum Ltd	27 000	0	0	0	0	0	6 712	14 529
Total	112 040	51 772	58 741	62 870	65 166	68 538	85 964	76 930

[a] April-December

Sources

1 MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas*** New Delhi: Ministry of Petroleum and Natural Gas.

2 MoPNG. 2001 ***Annual Report 2000/01***. New Delhi: Ministry of Petroleum and Natural Gas

Table 1.41 Refinery crude throughput and production (**thousand tonnes**) of petroleum products: 1990/91 to 1999/2000

Parameter	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Crude throughput	51 772	51 423	53 482	54 296	56 534	58 741	62 870	65 166	68 538	85 964
Production	48 562	48 349	50 359	51 084	52 927	55 081	59 005	61 308	64 544	79 417
Refinery losses	3 210	3 074	3 123	3 212	3 607	3 660	3 865	3 858	3 994	6 547
Losses (%)	6.2	6.0	5.8	5.9	6.4	6.2	6.1	5.9	5.8	7.5
Refinery capacity utilization (%)	–	99.2	103.1	102.9	105.9	104.2	104.1	105.9	99.1	76.7

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi: Ministry of Petroleum and Natural Gas.

3 MoPNG. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.42 Production (thousand tonnes) of petroleum products: 1990/91 to 2000

Petroleum products	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000*[a]
Light distillates											
Liquefied petroleum gas	1 221	1 250	1 249	1 314	1 432	1 539	1 598	1 666	1 724	2 487	3 074
Motor gasoline	3 552	3 420	3 709	3 843	4 129	4 462	4 704	4 849	5 573	6 232	5 998
Naphtha	4 859	4 546	4 586	4 666	5 662	5 975	6 123	6 103	6 081	8 170	7 560
Others	391	457	422	295	402	457	458	414	398	1 425	2 320
Total	10 023	9 673	9 966	10 118	11 625	12 433	12 883	13 032	13 776	18 314	18 952
Middle distillates											
Kerosene	5 471	5 339	5 199	5 266	5 261	5 267	6 236	6 701	5 341	5 735	6 446
Aviation turbine fuel	1 801	1 539	1 636	1 788	1 968	2 127	2 119	2 147	2 289	2 292	1 843
High speed diesel oil	17 185	17 404	18 289	18 809	19 593	20 661	22 202	23 354	26 716	34 793	29 162
Light diesel oil	1 509	1 482	1 453	1 474	1 364	1 351	1 286	1 246	1 336	1 624	1 088
Others	378	607	427	462	509	535	580	485	486	551	554
Total	26 344	26 371	27 004	27 799	28 695	29 941	32 423	33 933	36 168	44 995	39 093
Heavy ends											
Furnace oil	4 879	5 430	6 359	6 163	5 728	5 351	5 980	6 771	6 407	6 559	4 716
Low sulphur-heavy stock[b]	4 550	4 207	4 044	4 141	4 094	4 228	4 318	4 309	4 623	4 793	3 725
Lube oils	561	390	533	489	504	633	619	593	586	728	487
Petroleum coke	229	216	221	233	259	256	246	282	286	465	1 824
Bitumen	1 603	1 710	1 862	1 874	1 845	2 032	2 283	2 158	2 419	2 485	1 951
Others	373	352	370	267	177	207	252	230	279	1 072	650
Total	12 195	12 305	13 389	13 167	12 607	12 707	13 698	14 343	14 600	16 102	13 353
Grand total	48 562	48 349	50 359	51 084	52 927	55 081	59 005	61 308	64 544	79 411	71 398

[a] April-December 2000

[b] includes hot heavy stock and residual fuel oil

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas

2 MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE + [Section: Oil and gas (refining capacity, throughput, stocks)]

Table 1.43 Crude oil and petroleum products trade (quantity and value): 1990/91 to 1999/2000

Imports / Exports	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]
Crude oil										
Imports										
Gross quantity (thousand tonnes)	20 699	23 994	29 247	30 822	27 349	27 342	33 906	34 494	39 808	44 989
Gross value (million rupees)	61 184	78 201	106 859	106 885	103 160	115 170	185 381	158 971	148 764	306 953
Net quantity (thousand tonnes)	20 699	23 994	29 247	30 822	27 349	27 342	33 906	34 494	39 808	44 989
Net value (million rupees)	61 184	78 201	106 859	106 885	103 160	115 170	185 381	158 971	148 764	306 953
Petroleum products										
Imports										
Gross quantity (thousand tonnes)	8 660	9 445	11 283	12 076	13 951	20 335	20 265	19 530	18 780	13 067
Gross value (million rupees)	46 602	52 183	63 596	70 414	75 217	125 779	156 334	124 319	98 365	111 190
Net quantity (thousand tonnes)	6 012	6 509	7 564	8 042	10 697	16 900	17 103	16 576	17 379	12 141
Net value (million rupees)	36 563	40 036	47 533	55 326	59 343	107 459	135 538	106 039	89 808	103 844
Exports										
Gross quantity (thousand tonnes)	2 648	2 936	3 719	4 034	3 254	3 435	3 162	2 954	1 401	926
Gross value (million rupees)	10 039	12 147	16 063	15 088	15 874	18 319	20 796	18 280	8 557	7 346

[a] provisional

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas.*** New Delhi: Ministry of Petroleum and Natural Gas.

3 MoPNG. 2000. ***Annual Report 1999/2000.*** New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (exports and imports)]

Table 1.44A Imports (thousand tonnes) of crude oil and petroleum products: 1990/91 to 2000

Imports[a]	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000*[b]
Crude oil	20 699	23 994	29 247	30 822	27 349	27 342	33 906	34 494	39 808	44 989	57 158
Petroleum, oil, and lubricants											
Light distillates											
Naphtha	–	–	–	–	–	–	–	–	–	–	–
Liquefied petroleum gas	329	215	328	410	592	678	1 035	1 087	1 525	1 377	500
Others	5	47	8	4	2	439	455	335	422	241	234
Sub-total	334	262	336	414	594	1 117	1 490	1 422	1 947	1 618	734
Middle distillates											
Aviation turbine fuel	27	24	–	–	78	97	150	55	–	1	–
Kerosene	3 340	3 367	3 463	3 946	4 240	5 001	4 279	3 812	5 823	5 491	2 003
High speed diesel	4 680	5 329	7 159	7 555	8 637	12 852	13 608	14 075	10 485	5 408	–
Sub-total	8 047	8 720	10 622	11 501	12 955	17 950	18 037	17 942	16 308	10 900	2 003
Heavy ends											
Furnace oil	–	–	–	–	267	1 209	694	141	514	483	370
Lubes	256	412	296	132	87	58	44	25	11	66	27
Waxes	23	25	29	29	20	–	–	–	–	–	3
Refined petroleum coke	–	26	–	–	–	–	–	–	–	–	–
Others	–	–	–	–	28	–	–	–	–	–	–
Sub-total	279	463	325	161	402	1 268	738	166	525	549	400
Total imports	8 660	9 445	11 283	12 076	13 951	20 335	20 265	19 530	18 780	13 067	3 137

[a] includes national oil company imports but excludes imports made by private companies

[b] April–December

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (exports and imports)]

Table 1.44B Exports (**thousand tonnes**) of crude oil and petroleum products: 1990/91 to April-December 2000

Exports	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000*[a]
Crude oil	–	–	–	–	–	–	–	–	–	–	–
Petroleum, oil, and lubricants											
Light distillates											
Naphtha	1520	1423	1518	1625	2249	2461	2184	1407	643	241	254
Liquefied petroleum gas	–	–	–	9	12	17	22	21	23	31	26
Others	604	694	917	803	609	539	437	670	113	38	34
Sub-total	2124	2117	2435	2437	2870	3017	2643	2098	779	310	314
Middle distillates											
High speed diesel/light diesel oil	82	125	146	155	182	209	216	237	260	278	199
Others	79	107	129	137	170	187	221	254	271	309	240
Sub-total	161	232	275	292	352	396	437	491	531	587	439
Heavy ends											
Furnace oil/low sulphur heavy stock	357	583	1003	1288	29	22	82	360	91	29	16
Others	6	4	6	17	3	–	–	1	–	–	–
Sub-total	363	587	1009	1305	32	22	82	361	91	29	16
Total exports	2648	2936	3719	4034	3254	3435	3162	2950	1401	926	769

[a] April-December

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (exports and imports)]

Table 1.45 Movement of petroleum products by railways: 1990/91 to 1999/2000

Item	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Tonnes originating (thousand tonnes)	24 988	25 555	26 412	25 950	27 724	28 909	28 516	30 727	32 993	34 260
Average lead distance (km)	605	606	603	638	655	667	652	640	616	544
Earnings (paise/tonne-km)	63.6	66.3	73.7	88.9	99.1	103.7	109.2	128.3	126.7	132.6

Source

MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

Table 1.46 Petroleum products handled at major ports (**million tonnes**)

Port	*Port capacities as on 31 March 1999*	*1996/97*	*1997/98*	*1998/99*	*Utilization in 1998/99 (%)*
Calcutta	3.4	2.5	3.8	3.1	110
Chennai	8.5	12.5	11.6	8.5	100
Haldia	11.0	8.5	10.6	8.5	129
Kandla	29.0	25.1	29.0	23.0	126
Kochi	10.5	9.2	9.8	10.5	100
Mormugao	1.5	1.2	1.1	1.5	100
Mumbai	21.0	18.7	16.7	21.0	100
New Mangalore	7.5	4.9	6.5	7.5	100
Paradip	1.5	1.7	1.7	0.7	214
Tuticorin	1.0	0.4	0.4	1.1	91
Visakhapatnam	10.8	13.4	12.1	11.5	94
Total	105.7	98.1	104.0	96.9	109

Source

MoST. 1999. ***Basic Port Statistics 1998/99***. New Delhi: Ministry of Surface Transport.

Table 1.47 Product storage and movement: 1993/94 to 1999/2000

Mode of transport	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Road (MT [million tonnes])	15.3	17.9	22.2	[?]	[?]	[?]	[?]
	(25.2)	(27.3)	(30.6)	[?]	[?]	[?]	[?]
Rail (MT)	26.1	28	30.2[a]	29.6[a]	32[a]	33.9	35.1
	(42.9)	(42.8)	(41.7)	(38.3)	(39.9)	[?]	[?]
Pipelines (MT)	15	15.4	15.9	19.2	21.1	23.9	27.8
	(24.7)	(23.5)	(21.9)	(24.9)	(16.6)	[?]	[?]
Coastal (MT)	4.9	4.6	5.5	–	–	[?]	[?]
	(8.1)	(7.0)	(7.6)	–	–	[?]	[?]

[a] includes non-revenue earning traffic

Note

Values in parentheses indicate percentages

Source

MoPNG. 1999. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi. Ministry of Petroleum and Natural Gas.

Table 1.48 Sales/consumption of petroleum products (**thousand tonnes**): 1990/91 to 2000

Products	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000*[a]
Light distillates											
Liquefied petroleum gas	2 415	2 650	2 866	3 113	3 434	3 849	4 184	4 581	5 041	6 029	4 800
Motor gasoline	3 545	3 573	3 595	3 834	4 141	4 679	4 955	5 182	5 507	5 909	4 913
Naphtha	3 446	3 461	3 382	3 191	3 400	3 669	4 015	4 716	6 652	7 970	5 951
Others	395	431	467	432	662	947	1 230	1 263	758	565	303
Total	9 801	10 115	10 310	10 570	11 637	13 144	14 384	15 742	17 958	20 473	15 967
Middle distillates											
Kerosene	8 423	8 377	8 478	8 704	8 964	9 317	9 646	9 878	10 599	10 731	7 995
Aviation turbine fuel	1 677	1 559	1 565	1 741	1 903	2 082	2 158	2 108	2 112	2 197	1 658
High speed diesel	21 139	22 680	24 293	25 878	28 261	32 254	35 014	36 071	37 217	39 287	28 714
Light diesel oil	1 506	1 462	1 407	1 370	1 369	1 311	1 223	1 235	1 278	1 512	1 096
Others	361	326	409	453	479	495	498	424	480	532	426
Total	33 106	34 404	36 152	38 146	40 976	45 459	48 544	49 716	51 686	54 259	39 889
Heavy ends											
Furnace oil	4 462	4 937	5 273	5 026	5 837	6 496	6 534	6 651	6 767	6 816	4 712
Low sulphur heavy stock/ hot heavy stock	4 524	4 265	3 994	4 166	4 052	4 189	4 313	4 323	4 537	4 763	3 672
Lube oils/greases	892	932	846	688	668	711	705	835	885	915	550
Bitumen	1 581	1 706	1 823	1 824	1 939	2 005	2 273	2 178	2 412	2 879	1 837
Petroleum coke	290	266	152	132	197	319	276	227	315	328	273
Others	379	349	352	260	180	195	195	166	206	218	157
Total	12 128	12 455	12 440	12 096	12 873	13 915	14 296	14 380	15 122	15 919	11 201
Imports by private parties	–	–	–	–	1 886	2 152	1 944	4 452	5 796	5 639	4 679
Grand total	55 035	56 974	58 902	60 812	67 373	74 670	79 168	84 290	90 562	96 290	71 736

[a] April–December

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.
2 MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi: Ministry of Petroleum and Natural Gas.
3 MoPNG. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (sales and consumption)]

Table 1.49 Average annual compound growth rates of consumption of petroleum products (%)

Product	*Eighth Plan (1992-97)*	*Annual Plan (1996/97)*	*Annual Plan (1997/98)*	*Annual Plan (1998/99)*	*Annual Plan (1999/2000)*[a]
Light distillates	6.9	9.4	9.4	14.1	14
Liquefied petroleum gas	9.2	8.7	9.5	10.0	19.6
Motor spirit	6.4	5.9	4.6	6.3	7.3
Naphtha	2.2	9.4	17.5	41.1	19.8
Others	23.6	16.2	2.7	–40.0	–25.5
Middle distillates	6.7	6.8	2.4	4.0	5
Aviation turbine fuel	6.2	3.7	–2.3	–0.2	4
Superior kerosene oil	2.6	3.5	2.4	7.3	1.2
High speed diesel	8.6	8.6	3.0	3.2	5.6
Light diesel oil	–4.1	–6.7	1.0	3.5	18.3
Others	9.1	0.6	–14.9	13.2	10.8
Heavy ends	2.5	2.7	0.6	5.2	5.3
Lubes	0.1	–0.8	18.4	6.0	3.4
Fuel oil/low sulphur heavy stock	2.7	1.5	1.2	3.0	2.4
Bitumen	7.2	13.4	–4.2	10.7	19.4
Others	–3.3	–8.2	–16 6	32.6	4.8
Total consumption	5.9	6.5	3.4	6.2	6.9

[a] provisional

Source
MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.50 Consumption (**thousand tonnes**) of major petroleum products: 1999/2000 (PSU sales only)

State / Union Territory / Others	Naphtha	*Liquefied petroleum gas*	*Motor spirit*	*Superior kerosene oil*	*Aviation turbine fuel*	*High speed diesel*	*Light diesel oil*	*Furnace oil*	*Low sulphur heavy stock/ hot heavy stock*	*Lubes/ greases*	*Others*	*Total*
State												
Andhra Pradesh	439	434	437	683	48	3 450	40	486	134	52	280	6 483
Arunachal Pradesh	0	7	15	14	2	57	0	0	0	2	0	97
Assam	50	99	59	280	64	366	3	53	7	7	145	1 133
Bihar	1	173	169	869	8	1 739	88	254	113	40	267	3 721
Delhi	0	450	536	206	564	1 242	101	9	8	32	106	3 254
Goa	294	30	37	28	31	220	5	153	0	5	12	815
Gujarat	2614	419	503	839	70	2 959	239	650	1353	76	543	10 265
Haryana	0	251	206	182	26	2 004	63	165	343	23	131	3 394
Himachal Pradesh	0	56	39	51	0	254	4	16	16	4	24	464
Jammu and Kashmir	0	61	62	154	26	209	7	19	5	5	18	566
Karnataka	127	310	382	537	98	2 155	29	480	149	34	107	4 408
Kerala	632	217	289	308	82	1 313	5	261	294	30	192	3 623
Madhya Pradesh	79	264	282	668	24	2 366	80	516	32	41	164	4 516
Maharashtra	1015	941	837	1 587	604	4 256	336	1284	841	198	643	12 542
Meghalaya	0	8	18	21	0	111	0	0	0	1	10	169
Manipur	0	12	10	22	3	29	0	0	0	0	5	81
Mizoram	0	10	8	8	0	22	1	0	0	0	1	50
Nagaland	0	7	10	15	1	21	0	0	0	0	5	59
Orissa	63	62	96	344	16	723	12	243	0	16	35	1 610
Punjab	13	286	398	369	61	2 331	35	209	633	31	191	4 557
Rajasthan	526	247	248	455	47	2 687	65	178	80	27	151	4 711
Sikkim	0	4	4	12	0	13	1	2	0	0	0	36
Tamil Nadu	759	513	491	743	173	3 484	42	1135	428	126	388	8 282
Tripura	0	11	7	33	2	42	0	1	0	0	5	101
Uttar Pradesh	1261	781	493	1 420	101	4 856	167	339	307	68	448	10 241
West Bengal	97	320	172	830	109	1 925	166	277	0	63	594	4 553
Total	7970	5973	5808	10 678	2160	38 834	1489	6730	4743	881	4465	89 731

Union Territory												
Andaman and Nicobar Islands	0	2	4	7	5	64	0	0	0	1	5	88
Chandigarh	0	31	63	14	31	77	4	10	19	2	32	283
Dadra and Nagar Haveli	0	2	5	3	0	99	9	18	0	27	2	165
Daman and Diu	0	2	5	5	0	29	4	26	0	0	4	75
Lakshadweep	0	0	0	0	0	6	0	0	0	0	0	6
Pondicherry	0	16	20	15	0	148	3	29	1	2	6	240
Total	0	53	97	44	36	423	20	83	20	32	49	857
Others												
Bhutan	0	3	4	9	1	30	0	3	0	1	7	58
Nepal	0	0	0	0	0	0	0	0	0	1	4	5
Total	0	3	4	9	1	30	–[a]	3	0	2	11	63
Grand total	7970	6029	5909	10 731	2197	39 287	1509	6816	4763	915	4525	90 651

[a] negative

Source

MoPNG *Indian Petroleum and Natural Gas Statistics. 1999/2000* New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

For more details, please see **TEDDY ONLINE+** [Section: Oil and gas (sales and consumption)]

Table 1.51 Offtake (**million cubic metres**) of natural gas by industry: 1990/91 to 1999/2000

Industry	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*[a]	*1996/97*[a]	*1997/98*[a]	*1998/99*[a]	*1999/2000*[a]
Energy purposes										
Power generation	3 634	4 774	4 967	4 785	5 229	6 836	6 935	8 114	8 714	9 143
Industrial fuel	827	766	1 450	1 794	1 927	2 301	2 631	3 106	3 005	2 502
Tea plantation	89	108	105	121	134	111	130	117	147	147
Domestic fuel	50	72	187	189	190	178	184	206	193	257
Captive use/Liquefied petroleum gas	1 775	2 165	1 916	2 277	2 230	589	618	569	911	900
Total	6 375	7 885	8 625	9 166	9 710	10 015	10 498	12 112	12 970	12 949
Non-energy purposes										
Fertilizer industry	5 612	5 509	6 672	6 499	6 936	7 602	7 625	8 752	8 869	8 917
Petrochemicals	409	531	578	494	520	474	509	649	650	686
Others	370	516	241	181	173	–	–	–	–	1 254
Total	6 391	6 556	7 491	7 174	7 629	8 076	8 134	9 401	9 519	10 857
Grand total	12 766	14 441	16 116	16 340	17 339	18 091	18 632	21 513	22 489	23 806

[a] excludes some sales by the Oil and Natural Gas Corporation Ltd

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas.*** New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (sales and consumption)]

Table 1.52 Subsidies on major petroleum products and subsidies by the central government (**million rupees**): 1991/92 to 1999/2000

Product	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]
Kerosene (domestic use)	23 640	33 040	37 730	37 400	41 900	65 400	58 200	57 700	81 200
High speed diesel	480	1 200	5 750	4 300	21 800	80 900	–	–	50 000
Liquefied petroleum gas (packed) (domestic use)	8 770	11 760	12 610	14 100	16 300	22 200	16 600	26 000	47 300
Naphtha/Fuel oil/Low sulphur heavy stock (fertilizer use)	6 610	8 150	7 720	8 500	12 000	15 200	–	–	–
Bitumen (packed)	1 250	1 520	1 260	1 100	1 200	2 000	–	–	–
Paraffin wax	1 000	1 190	890	200	400	300	–	–	–
Total	41 750	56 860	65 960	65 600	93 600	186 000	74 800	83 700	178 500
Total central government subsidies	122 530	119 950	126 820	129 320	133 720	161 250	196 440	220 250	–
POL products[b]	41 750	56 860	65 960	65 600	93 600	186 000	74 800	83 700	178 500
Total subsidy	164 280	176 810	192 780	194 920	227 320	347 250	271 240	303 950	–
POL subsidy as percentage of total subsidy	25.41	32.16	34.22	33.65	41.18	53.56	27.58	27.54	–

[a] provisional

[b] these do not form part of the government budget

Source

MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas.*** New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.53 Development of spot prices of key Organization of the Petroleum Exporting Countries crudes **(dollars per barrel)**: 1998 to 2000

Year / Month	*Arab light*	*Arab heavy*	*Iranian light*	*Kuwait (export)*	*Saharan blend*	*Dubai*
1998						
January	13.61	12.11	13.40	12.80	15.56	13.41
February	12.80	11.10	12.34	11.69	14.48	12.41
March	11.67	9.77	11.31	10.61	13.49	11.53
April	12.18	10.53	11.98	10.99	13.82	12.23
May	12.73	11.33	12.53	11.55	14.55	12.75
June	11.88	10.48	11.68	10.73	12.06	11.80
July	11.87	10.47	11.67	10.97	12.47	12.11
August	12.48	11.36	12.28	11.33	12.41	12.25
September	13.17	12.17	12.97	12.39	13.73	13.08
October	12.72	11.82	12.52	12.01	12.83	12.69
November	11.92	11.07	11.72	11.24	11.25	11.96
December	9.90	9.15	9.80	9.31	10.23	10.11
1999						
March	12.11	11.31	11.99	11.54	12.73	12.39
April	14.92	13.72	14.67	14.17	15.10	14.90
May	15.60	14.60	15.37	14.82	15.23	15.46
June	15.41	14.51	15.24	14.73	15.78	15.46
July	17.85	16.80	17.65	17.10	19.40	17.90
August	19.58	18.45	19.31	18.76	20.52	19.45
September	22.35	21.30	22.12	21.65	22.86	22.08
October	22.18	21.03	22.03	21.53	22.27	21.48
November	23.66	22.81	23.51	23.13	25.05	23.08
December	25.04	23.70	24.81	24.20	26.13	23.65
2000						
January	24.43	23.08	24.35	23.70	25.89	23.23
February	25.85	24.00	25.70	24.84	28.74	24.77
March	26.02	24.52	25.87	25.07	27.65	24.99
April	22.95	22.00	22.86	22.29	22.91	22.14
May	26.97	25.27	26.10	25.60	28.02	25.69
June	29.09	27.09	27.99	27.44	29.94	27.24
July	27.19	25.99	27.09	26.39	28.76	26.35
August	27.12	25.52	27.12	26.21	29.25	26.79
September	30.60	28.00	30.45	29.05	33.18	30.05
October	30.17	28.21	30.42	28.87	31.19	30.57
November	29.81	27.94	29.75	28.20	33.06	30.25
December	22.65	20.83	22.66	21.11	26.11	22.27

Note
Figures are weekly averages.

Source
OPEC. *Monthly Bulletin* (various issues). Vienna: Organization of the Petroleum Exporting Countries.

Table 1.54 Realization of excise and customs duties from crude oil and petroleum products (**million rupees**): 1990/91 to 1999/2000

Products	*1990/91*	*1992/93*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]
Excise duties								
Motor spirit	12 020	12 870	15 240	16 310	21 170	29 420	44 420	50 010
Kerosene oil	2 550	2 390	3 060	2 580	6 470	2 260	2 380	2 490
Refined diesel oil	6 930	7 430	11 810	11 550	19 620	20 520	31 390	67 690
Diesel oil	350	340	1 070	800	12 300	1 450	1 540	12 340
Furnace oil	490	640	1 840	1 460	2 890	5 440	3 060	6 160
POL products (no.)	4 210	4 270	5 840	7 330	8 810	18 990	22 020	27 140
Petroleum gases	660	790	2 000	2 760	3 820	3 970	3 790	3 590
Cess on crude oil	27 570	21 690	26 100	28 800	26 750	27 400	26 340	32 430
Sub-total	54 780	50 420	66 960	71 590	90 760	109 450	134 940	201 850
Customs duties								
Crude petroleum	31 460	40 530	34 640	40 520	57 400	48 670	32 300	62 570
Petroleum products	5 550	12 270	27 450	44 010	57 840	51 590	47 890	62 030
Sub-total	37 010	52 800	62 090	84 530	115 240	100 260	80 190	124 600
Grand total	91 790	103 220	129 050	156 120	206 000	209 710	215 130	326 450

[a] revised estimates

Source

MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.55 Development of (ex-storage point) basic ceiling selling prices (**rupees per selling unit**) of petroleum products: 1990 to 1999

Product	*20 March 1990*	*15 October 1990*	*25 July 1991*	*16 September 1992*	*2 February 1994*	*1 March* 1994 to *1 March 1995*[a]	*7 July 1996*	*2 September 1997*	*17 January 1998*	*1 April 1998*	*February 1999*
Aviation turbine fuel (domestic) (kilolitres)	6 560	8 200	9 840	10 838	10 838	9 852	10 838	10 838	10 838	10 838	10 759
Motor spirit 83/87	8 944	11 180	13 416	14 413	15 413	12 844	16 055	17 055	17 055	17 055	15 399
Motor spirit 93	10 944	13 680	16 416	17 413	18 413	15 344	19 180	20 180	20 180	20 180	18 239
High speed diesel oil[b]	3 634	4 542	4 542	5 539	6 289	5 717	6 575	8 375	8 375	7 837	6 622
Superior kerosene oil (domestic)[b]	1 957	2 446	2 202	2 202	2 202	2 001	2 001	2 001	2 001	2 001	2 001
Light diesel oil	3 054	3 817	4 199	5 396	6 146	5 588	7 264	7 264	7 264	7 201	6 300
Furnace oil (kilolitres)											
For non-fertilizer	2 903	3 629	3 992	4 989	4 989	4 535	5 896	5 143	5 143	4 801	4 050
For fertilizer[c]	1 320	1 650	1 815	2 812	2 812	2 812	3 656	5 143	5 143	4 801	–
Low sulphur heavy stock (tonnes)											
For fertilizer[c]	1 349	1 686	1 854	2 852	2 852	2 852	3 707	6 089	6 089	5 071	4 340
For non-fertilizer	2 769	3 461	3 807	4 804	4 804	4 804	6 245	6 089	6 089	5 071	0
Bitumen straight grade (tonnes)											
Bulk	2 575	3 219	3 540	4 538	4 538	4 125	5 363	5 600	5 600	5 600	5 600
Packed	3 100	3 875	4 262	5 259	5 259	4 781	6 216	7 050	7 050	7 050	7 050
Naphtha (tonnes)											
For non-fertilizer[b]	3 211	4 014	4 415	6 076	6 076	6 076	6 683	7 624	7 444	7 072	6 820
For fertilizer[b]	1 982	2 478	2 726	3 723	3 723	3 723	4 840	7 624	7 444	7 072	6 820
Liquefied petroleum gas (packed) (tonnes)											
Domestic	3 449	3 449	4 139	5 136	5 840	5 309	6 902	7 958	7 958	7 958	8 733
Non-domestic (essential)[d]	5 001	6 251	6 877	12 588	12 588	11 443	0	0	0	0	0
Non-domestic (non-essential)[d]	6 151	7 689	8 458	14 169	14 169	12 881	13 900	14 303	14 303	10 015	12 669

---

[a] from 1 March 1994 onwards, customs and excise duties on all petroleum products were on *ad valorem* basis with only two rates. Motor spirit and coal tar would attract 20% duty. All other petroleum products would be charged central excise duty at 10%.

[b] effective 26 March 1985.

[c] prices are exclusive of customs and excise duties

[d] from 17 May 1995 onwards, the two categories under non-domestic liquefied petroleum gas (packed) for essential and non-essential uses have been merged together with a price of 12 881 rupees per million tonne

Notes

1 Prices have been rounded off to the nearest rupee.

2 From 1 October 1986 onwards, jute batching oil, special boiling point spirit 64/69, hexane, mineral turpentine oil 140/205, and mineral turpentine oil have been kept outside the pricing scheme; low sulphur heavy stock has been brought under the pricing scheme.

Sources

1 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues) New Delhi: Economics and Statistics Division, Ministry of Petroleum and Natural Gas

2 MoPNG. 1998. ***Basic Statistics on Indian Petroleum & Natural Gas.*** New Delhi. Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Oil and gas (prices)]

Table 1.56 Retail selling price of selected petroleum products in metropolitan cities and towns: 1996 to 2000

							Aviation turbine fuel	
City	*MS-87 (rupees per litre)*	*High speed diesel (rupees per litre)*	*Superior kerosene oil (rupees per litre)*	*Light diesel oil (rupees per kilolitre)*[a]	*Furnace oil (rupees per kilolitre)*[a]	*Liquefied petroleum gas (rupees per 14.2 kg cylinder)*	*Domestic airlines (rupees per kilolitre)*[c]	*International airlines (dollars per kilolitre)*
2 January 1996								
Chennai	19.98	7.80	2.80	6 321.80	5 155.63	98.05	11 273.25	288.25
Delhi	16.95	6.99	2.57	6 287.47	5 163.46	93.78	10 999.50	251.07
Kanpur	18.12	7.69	2.85	6 487.14	–[b]	98.87	11 224.20	–
Kolkata	17.68	7.25	2.80	6 251.08	5 091.23	106.99	11 074.96	296.40
Mumbai	19.26	7.84	2.55	6 267.59	5 104.22	94.37	11 134.82	278.96
3 July 1996								
Chennai	24.91	8.95	2.80	8 145.10	6 668.95	123.81	12 400.58	268.61
Delhi	21.13	8.02	2.57	8 133.86	6 662.60	119.95	12 088.70	233.95
Kanpur	22.53	8.79	2.85	8 331.53	–[b]	126.24	12 312.65	–
Kolkata	22.05	8.32	2.80	8 103.19	6 695.68	136.66	12 180.42	276.20
Mumbai	24.03	9.00	2.55	8 123.61	6 612.40	120.90	12 248.30	259.94
1 April 1997								
Chennai	24.91	8.86	2.80	8 183.24	6 668.95	124.10	15 376.72	325.93
Delhi	21.13	8.02	2.58	8 131.60	6 659.63	119.95	13 073.67	283.88
Kanpur	22.40	8.65	2.80	8 182.00	–[b]	126.25	13 860.60	–
Kolkata	22.05	8.32	2.80	8 103.19	6 695.68	136.65	15 530.04	335.13
Mumbai	24.03	9.00	2.55	8 123.61	6 612.40	118.60	15 922.79	315.42
2 September 1997								
Chennai	26.79	11.39	2.81	8 183.24	5 955.98	145.05	15 376.72	325.93
Delhi	23.84	10.34	2.56	8 131.60	5 831.04	136.00	13 073.67	283.88
Kanpur	23.77	10.97	2.80	8 182.00	–	144.40	13 860.60	–
Kolkata	23.55	10.63	2.80	8 103.19	5 796.59	158.55	15 682.30	335.13
Mumbai	25.79	11.53	2.55	8 123.61	5 809.68	137.85	15 922.79	315.42
1 January 1998								
Chennai	26.79	11.45	2.80	8 183.24	5 685.25	145.05	15 376.72	–
Delhi	22.84	10.39	2.56	8 131.60	5 572.63	136.00	13 073.67	–
Kanpur	23.76	11.06	2.79	8 182.00	–[b]	144.38	13 860.60	–
Kolkata	23.54	10.08	3.05	8 103.19	5 505.96	158.55	15 682.30	–
Mumbai	25.79	11.58	2.55	8 123.61	5 520.83	137.85	15 922.79	–
1 April 1998								
Chennai	26.79	11.30	2.80	8 482.96	5 833.95	145.05	15 376.72	–
Delhi	22.84	10.25	2.56	8 440.01	5 717.72	136.00	13 073.67	–
Kanpur	23.76	10.85	2.79	8 508.67	–[b]	144.38	13 860.60	–
Kolkata	23.54	10.55	3.05	8 401.64	5 669.86	158.55	15 682.30	–
Mumbai	25.79	11.43	2.55	8 420.62	5 741.49	137.85	15 922.79	–

Continued

Table 1.56 continued

City	MS-87 (rupees per litre)	High speed diesel (rupees per litre)	Superior kerosene oil (rupees per litre)	Light diesel oil (rupees per kilolitre)[a]	Furnace oil (rupees per kilolitre)[a]	Liquefied petroleum gas (rupees per 14.2 kg cylinder)	Aviation turbine fuel: Domestic airlines (rupees per kilolitre)[c]	Aviation turbine fuel: International airlines (dollars per kilolitre)
3 June 1998								
Chennai	28 14	11.30	2.80	8 482.96	5 833.95	145.05	15 376.72	–
Delhi	23 94	10 25	2 56	8 440 01	5 717.72	136.00	13 073 67	–
Kanpur	24 90	10 85	2.79	8 508 67	–[b]	144.38	13 860.60	–
Kolkata	24 70	10.55	3 05	8 401 64	5 669.86	158.55	15 682.30	–
Mumbai	27 07	11.43	2.55	8 420.62	5 741.49	137.85	15 922 79	–
1 October 1998								
Chennai	28.14	10 89	2.80	[?]	[?]	145 05	12 426.46	171.71
Delhi	23 94	9.87	2.56	[?]	[?]	136.00	12 107.33	171.71
Kanpur	23 76	10.60	2.80	[?]	[?]	144.38	12 172.59	171.71
Kolkata	24 70	10.16	3.05	[?]	[?]	158 55	12 204.11	171.71
Mumbai	27.07	11.01	2.55	[?]	[?]	137 85	12 272 80	171.71
1 April 1999								
Chennai	27.99	10.91	2.76	[?]	[?]	155 35	12 426.46	166.43
Delhi	24.01	10 03	2.51	[?]	[?]	146 00	12 107.33	166.43
Kanpur	26.06	10 92	2 75	[?]	[?]	154 95	12 172.59	166.43
Kolkata	24.56	10.18	3.01	[?]	[?]	170.00	12 204.11	166.43
Mumbai	28.25	11.84	2.63	[?]	[?]	147.85	12 272.80	166.43
1 April 2000								
Chennai	27 99	15.24	5.64	14 612.61	12 893.54[e]	202.40	18 448.94	321.02
Delhi	26.07[d]	14 56	5 55	–	–[e]	196 55	17 217.53	310.67
Kanpur	26 08	15.17	5.95	–	–	204.50	17 664.32	[?]
Kolkata	26 33	14.20	5.84	12 259 77	13 328.40[e]	217.20	18 245.823	33 32
Mumbai	28.47	16.91	5.37	13 994.93	12 427.33[e]	199.00	18 243.90	310.67

[a] no retail sale, ex-depot rates exclusive of sales tax

[b] no storage facility

[c] excluding sales tax and local levies

[d] MS unleaded (0.051 sulphur)

[e] general purpose

Sources

1 MoPNG *Indian Petroleum and Natural Gas Statistics* (various issues) New Delhi. Economics and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 1999. ***Basic Statistics on Indian Petroleum & Natural Gas.*** New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.57 Consumer prices of natural gas (**rupees**) (excluding royalty, taxes and all statutory levies)

Effective date	*Offshore (landfall point) and onshore*	*Gas along HBJ pipelines*	*For North-eastern states*
1 January 1995	1850	2700	1000
1 October 1997	2150	3300	1200
1 January 1998	2411	3561	1315
1 April 1998	2271	3421	1250
1 July 1998	2246	3396	1307
1 October 1998	2222	3372	1200
1 January 1999	2215	3365	1274
1 April 1999	2167	3317	1224
1 July 1999	2499	3649	1499
1 October 1999	2850	4000	1700
1 January 2000	2850	4000	1700
1 April 2000	2850	4000	1700

Notes

1. With effect from 1 October 1997 the price of gas has been linked to the price of a basket of LSHS fuel oils. The price is fixed on quarterly basis.
2. The price of gas was linked to a calorific value range of 9000-9500 kcal/m^3 during 1 May 1995 to 30 September 1997.
3. With effect from 1 October 1997 the price of gas is linked to calorific value of 10 000 kcal/m^3.
4. Gas price along HBJ pipelines includes Rs 1150/- towards HBJ transportation with effect from 1 October 1997. The aforesaid transportation charges are linked to the calorific value of 8500 kcal/m^3.
5. The discount of Rs 400 was applicable in case of gas prices for North-eastern states up to 30 September 1997. With effect from 1 October 1997 the applicable discount in case of gas prices for North-eastern states is Rs 300/1000 m^3.

Source

MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas*** New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.58 Eighth Plan outlay and actual expenditure of petroleum and natural gas **(million rupees)**

Undertakings	*Eighth Plan outlay*	*Actual expenditure*							*Eighth Plan total expenditure*	*Ninth Plan expenditure*	*1999/2000*[a]	*2000/01*[b]
		1992/93	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*				
Exploration and production	200 000	47 260	81 480	65 110	53 860	49 110	53 710	52 590	296 820	295 780	62 080	67 690
Oil and Natural Gas Corporation Ltd	175 110	42 490	77 220	60 040	42 500	39 730	40 050	44 680	261 980	201 990	49 290	52 030
Oil India Ltd	10 630	2 850	3 110	2 950	3 310	3 530	3 550	4 280	15 550	29 610	4 680	6 000
GAIL (Gas Authority of India Ltd)	14 260	2 120	1 150	2 120	8 050	5 850	10 110	3 630	19 290	64 180	8 110	9 660
Refining and marketing	40 000	9 720	14 420	21 330	27 370	30 970	43 120	59 540	103 810	477 180	60 110	6 380
IOC (Indian Oil Corporation Ltd)	24 050	3 660	6 730	15 370	20 790	16 040	17 130	26 880	62 590	254 880	34 180	4 270
BPCL (Bharat Petroleum Corporation Ltd)	1 300	550	750	480	1 310	2 260	5 030	5 750	5 350	6 540	4 390	4 580
HPCL (Hindustan Petroleum Corporation Ltd)	3 800	1 710	2 290	2 020	1 850	5 700	10 850	11 010	13 570	74 480	9 040	5 990
CPCL (Chennai Petroleum Corporation Ltd)	2 660	2 010	1 370	430	200	350	710	3 340	4 360	34 640	190	3 490
KRL (Kochi Refineries Ltd)	4 360	860	1 550	860	540	1 030	870	3 950	4 840	22 300	3 670	3 740
BRPL (Bongaigaon Refinery and Petrochemicals Ltd)	2 000	420	750	630	350	210	330	150	2 360	7 550	310	500
Lubrizol India Ltd	300	50	110	160	50	10	0	40	380	400	30	20
Engineers India Ltd	150	40	70	20	30	60	60	100	220	350	80	70
IBP Co. Ltd	1 390	420	470	310	350	1 170	930	1 560	2 720	0	1 900	1 500
NRL	0	0	330	1 050	1 900	4 140	7 210	6 760	7 420	17 180	4 610	1 210
Petrochemicals	24 270	830	1 610	2 560	6 060	7 660	4 150	3 810	18 720	–	1 750	2 690
BRPL	470	30	70	40	80	120	40	230	340	–	60	90
BPCL	2 500	10	20	70	190	5	0	0	295	–	10	20
KRL	400	90	30	100	0	0	0	40	220	–	30	10
CPCL	190	30	20	10	0	0	0	0	60	–	0	10
HPCL	400	80	10	0	0	0	0	0	90	–	0	10
GAIL	12 000	510	1 330	2 180	5 750	7 520	4 070	328	17 290	–	760	200
IOC	3 000	80	130	160	40	20	40	260	430	–	880	2 310
Engineering	1 250	170	100	220	260	270	430	420	1 020	11 050	770	440
IPC Co. Ltd and others	1 250	170	100	220	260	270	430	420	1 020	11 050	770	440
Grand total	265 520	57 980	97 610	89 220	87 550	88 010	10 410	116 360	420 370	784 010	124 710	134 620

[a] revised

[b] budget estimates

Source

MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.59A International petroleum statistics: 1990 to 1999

Item	*1990*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*
Reserves of oil and gas at the year end - R							
Crude oil (billion tonnes)							
World	136.5	137.3	138.3	140.9	142.3	143.4	140.4
OPEC	105.1	104.7	105.8	107.2	108.4	108.8	109.1
Natural gas (trillion cubic feet)							
World	4209	4980	4934	4991	5112	5170	5772
OPEC	1735	2034	2037	2112	2175	2207	2236
Production of oil and gas							
Crude oil - R (MT [million tonnes])							
World	3180	3213	3272	3371	3469	3533	3452
OPEC	1199	1319	1327	1371	1431	1490	1410
Natural gas - R Net (billion cubic metres)							
World	1991	2087	2131	2232	2231	2274	2330
OPEC - R	211	264	304	325	332	344	365
World oil refinery capacity (MTPA [million tonnes per annum])	3728	3756	3829	3874	3976	4006	4072
Crude throughput (MTPA)	3093	3099	3147	3224	3344	3361	3387
Oil consumption[a] (MT)							
World	3140	3135	3235	3316	3390	3407	3462
Main consuming areas	1423	1477	1478	1513	1518	1514	1560
Consumption in main areas as percent of world	45.4	46.3	45.7	45.5	44.8	44.7	45.1

OPEC - Organization of the Petroleum Exporting Countries; R - Based on BP conversion factor

[a] includes France, Germany, Italy, Japan, UK, and USA

Source

MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.59B International petroleum statistics: 1990 to 1999

Item	*1990*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*
World imports/exports (million tonnes)							
Imports							
Crude oil	1188	1376	1403	1449	1544	1585	1578
POL products	363	378	385	431	435	410	448
Total	1551	1754	1788	1880	1979	1995	2026
Exports from OPEC							
Crude oil	797	895	898	908	960	1019	–
POL products	176	187	205	213	233	231	–
Total	973	1082	1103	1121	1193	1250	–
World primary energy consumption (million tonnes of oil equivalent)							
Oil	3135	3189	3235	3316	3390	3407	3462
Natural gas	1771	1838	1912	2004	1989	2015	2064
Coal	2245	2185	2207	2286	2290	2239	2104
Hydroelectric	189	206	216	219	223	225	227
Nuclear energy	517	573	600	621	617	627	651
Total	7857	7990	8170	8446	8509	8513	8508

OPEC - Organization of the Petroleum Exporting Countries

Source

MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas.*** New Delhi: Ministry of Petroleum and Natural Gas.

Table 1.60 CNG (compressed natural gas) activities in India as on 1 April 2000

	Delhi	*Maharashtra*	*Gujarat*				
Item	*Delhi IGL*	*Mumbai MGL*	*Vadodara GAIL*	*Surat GGCL*	*Ankleshwar GGCL*	*Total*	*Grand Total*
Station type							
Mother	1	2	1	1	0	2	5
Online	3	8	0	1	0	1	12
Daughter Booster	2	8	0	0	0	0	10
Daughter	6	1	2	1	1	4	11
Total	12	19	3	3	1	7	38
No. of vehicles							
Cars	5 182	12 500	133	671	93	897	18 579
Buses	18	10	0	0	0	0	28
Total	5 200	12 510	133	671	93	897	18 607
Price (Rs/Kg)	11 3	14.8	11.2	18.66	19.28	–	–
Average consumption (March 2000)							
TPD	12.23	52.76	0.27	0.75	0.16	1.18	66.16
MMSCMD	0.015	0.066	0	0.001	0	0.001	0.082

Note

1 kg of CNG = 1.244 standard cubic metres of Gas = 1.391 litres of petrol on energy equivalent basis

Gail - Gas Authority of India Ltd; IGL - Indraprastha Gas Ltd; GGCL - Gujarat Gas Company Ltd; MGL - Mahanagar Gas Ltd; TPD - tonnes per day; MMSCMD - million standard cubic metres per day

Source

MoPNG. 2000. ***Basic Statistics on Indian Petroleum & Natural Gas***. New Delhi. Ministry of Petroleum and Natural Gas.

Your Indian Partner for World-Class Electrical Products

Business Segments

- LV Switchgear Components
- LV Controlgear Components
- LV Switchboards MCCs / PCCs
- Bus Ducts & Bus Bar Trunking Systems
- Power System Protection Relays
- Alternators 7.5kVA - 3000kVA
- Silent Diesel Gensets
- Wago Cage Clamp Terminals & Connection Systems
- RS Mail Order Catalogue & Service

CONTROL THE CONTROL GROUP

CONTROL CONTROLS & SWITCHGEAR COMPANY LTD.

RS Components & Controls (India) Ltd.

TC Telemecanique & Controls (India) Ltd.

WAGO Wago & Controls (India) Ltd.

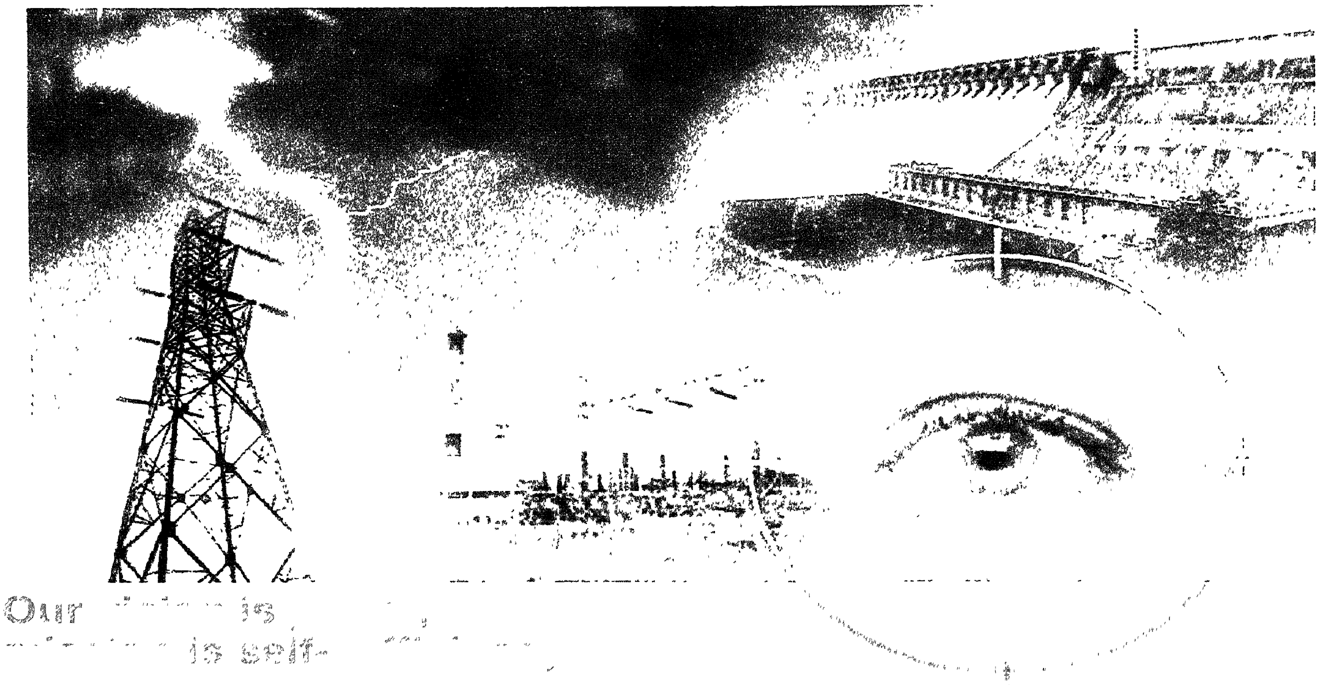
AVKC|SEGC AVK - SEG & Controls (India) Ltd.

RAAS CONTROLS

Corporate Office: The Control House 222, Okhla Industrial Estate, New Delhi - 110 020 (India) Ph.: (+91-11) 684 8242-45, 683 6171 Fax: (+91-11) 684 7154, 682 9063 e-mail: controls.cs222@elnet.ems.vsnl.net.in

Central Marketing Office: The Control House 222, Okhla Industrial Estate, New Delhi - 110 020 (India) Ph.: (+91-11) 691 8834-37, 683 2259 Fax: (+91-11) 684 7342, 684 8241 e-mail: info@controlsindia.com

Cyberspace : www.controlgroup.org



Power Finance Corporation Ltd. (PFC)has been spearheading India's power needs by financing power projects in State utilities and Private Sector.

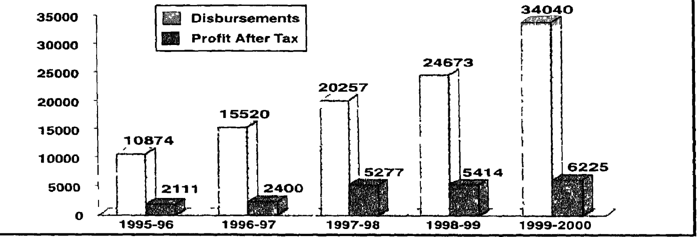
PFC primarily extends support for Studies, Consultancy and Training R&D, Capacitors, Energy Meters, Computerisation, Environmental upgradation, Transmission, Mini, Micro and Small Hydro Generation, Non-Conventional Energy Resources etc.

As part of its commitment, PFC offers comprehensive consultancy services in power that includes Project Planning, Financing, Design, Implementation, Managerial Services, etc.

PFC's expertise is amply reflected in its record 99% recovery rate with zero non-performing assets (NPAs).

PFC will continue to strive harder, since it recognises the gigantic task ahead, to make India a power to reckon within power.

Disbursements & Profit After Tax (Rupees in million)



RATINGS

# Standard & Poors	BB/Stable (Sovereign)
# Moody's	Ba2/Positive (Sovereign)
# Govt. of India	Excellent
# CRISIL & ICRA	Highest Safety

ECBs RAISED

- US$ 75 Million Syndicated Loan (50 bp above LIBOR) in January, 1997.
- US$ 100 Million Euronotes (7.5 fixed) in July, '97.
- US$ 100 Million Syndicated Loan (115 bp above US LIBOR) in July, 1998.
- US$ 100 Million FRN (145 bp above LIBOR) in July, 1999.

POWER FINANCE CORPORATION LTD.

(A Govt. of India Undertaking)
Chandra Lok, 36, Janpath, New Delhi-110 001. Website : http://www pfcindia com
FUNDING FOR A BRIGHTER TOMORROW

MCS COMM

Power

At a glance

- Installed capacity as on 31 March 2001 was 101 630 MW, of which 71% was thermal, 25% hydel, 3% nuclear, and 1% wind.
- Till 31 January 2001, 25 private sector projects had been commissioned with a total installed capacity of 5370 MW.
- In 2000/01, 499.45 billion units of power was generated. Energy deficits were estimated at 7.8% and peak deficit at 13%.
- Per capita consumption of electricity is estimated at 374 kWh.
- Capacity additions envisaged during the Ninth Five-Year Plan is 40 245 MW, of which 73% is thermal, 25% hydro, and 2% nuclear, but the rate of additions has been below target so far.
- Transmission and distribution losses are reported at 23% on an average. These losses are being reassessed, and it is evident that actual losses are much higher than reported losses.
- Power tariffs vary widely between states and between consumer categories. In 2000/01, the overall average tariff for the state electricity boards was Rs 2.12/kWh, which covered just 69.8% of the average cost of supply.
- The Union Cabinet approved the Accelerated Power Development Programme.
- The Ministry of Power, Government of India, signed memoranda of understanding with several state governments to affirm the joint commitment of the two parties to reform the power sector in the respective states.
- The state electricity regulatory commissions of Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Orissa, Rajasthan, and Uttar Pradesh have issued tariff orders.

Overview

The total installed capacity under utilities in India increased to 101 630 MW in 2000/01 from 97 845 MW in 1999/2000: 72 359 MW thermal, 25 142 MW hydel, 2860 MW nuclear, and 1269 MW wind power (Table 1.65).

There was a corresponding increase in electricity generation to 499 450 MU (million units) from 480 000 MU recorded in 1999/2000: 408 208 MU thermal, 74 346 MU hydel, and 16 896 MU nuclear energy. The overall annual PLF (plant load factor) of thermal stations was 69% as compared with 67.3% in 1999/2000.

The peak demand met was 67 880 MW and the energy availability was 467 000 MU against the requirement of 78 037 MW and 507 000 MU, respectively. Thus, there was a shortage of 13% in meeting the peak demand and 7.8% in energy.

The per capita consumption for 2000/01 was estimated to be 374 kWh. As on 2000/01, 508 077 villages have been electrified out of

587 258 villages (provided by the CEA [Central Electricity Authority]).

The size and extent of the T&D (transmission and distribution) network has also increased over the years. As per the general review of the CEA, a T&D network of 5.5 million c-km (circuit-kilometres) up to 500 V and an aggregate transformation capacity of approximately 425 947 MVA (mega volt ampere) existed as on 1997/98.

About 6140 c-km of transmission lines (220 kV and above) and an aggregate transformation capacity of 12 250 MVA was achieved in 2000/01 as against the target of 7316 c-km for the former and 12 050 MVA for the latter.

The power system in the country has been demarcated into five regions for purposes of planning and operation. Fairly well-built EHV (extra high voltage) grids exist in all the regions, with a 400-kV AC functioning as the backbone of the grid. A few HVDC (high voltage direct current) lines and 765-kV (operated at 400 kV) links have also been established; interconnections between regions also exist as part of the evolution of a national power grid. The inter-regional power transfer capacity has increased from 1200 MW in 1996/97 to 4350 MW in 2000/01. The Indian power grid is also interconnected with the power systems of Bhutan and Nepal. The entire surplus power from the Chukha HE project (336 MW) in Bhutan is exported to India. This was 1400 MU during 2000/01. India also exports power to Nepal, though the quantum is limited. Power exchanges are taking place between states and between regions, depending on availability and demand of power. In 2000/01, about 9874 MU of energy was exchanged between regions through inter-regional links.

Some of the developments that have taken place during 2000/01 are listed below.

- The Union Cabinet approved the APDP (Accelerated Power Development Programme)
- The MoP (Ministry of Power), Government of India, signed MoUs (memoranda of understanding) with the governments of Andhra Pradesh, Assam, Gujarat, Haryana, Himachal Pradesh, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, and West Bengal to affirm the joint commitment of the two parties to reform the power sector in the respective states.
- The MoP, Government of India, signed an MoU with the Government of Uttaranchal to affirm the joint commitment of the two parties to upgrade the quality of service in the power sector in Uttaranchal and to carry forward the process of power sector reform initiated in the erstwhile Uttar Pradesh and reiterated in the MoU signed jointly by the Government of Uttar Pradesh and the Government of India.
- The Power Ministers' Conference held on 3 March 2001, chaired by the Prime Minister of India, gave added emphasis to power sector reforms, particularly to reforms in distribution and rural electrification.
- The SERCs (state electricity regulatory commissions) of Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Orissa, Rajasthan, and Uttar Pradesh issued tariff orders during 2000/01.
- An expert group has been set up by the MoP to recommend a one-time settlement of SEB dues for states undertaking reforms.

Capacity addition

The Ninth Five-Year Plan envisaged a total capacity addition of 40 245 MW: 9820 MW hydro, 29 545 MW thermal, and 880 MW nuclear power. This total capacity addition was scaled down to 28 097 MW in the mid-term review conducted in 1999. However, as per the review conducted by the MoP in August 2000, even this does not appear feasible, and the target has therefore been further scaled down to 21 564 MW. The sectoral break-up of the capacity added during the four years of the plan is given in Table I.

The fuel-mix of the capacity addition during 2000/01 was 2120 MW thermal, 1215 MW hydel, 440 MW nuclear, and 114 MW wind. Only about 74% of the (revised) plan targeted capacity has been achieved in the first four years of the Ninth Plan. In 2000/01, thermal and hydel capacity addition fell below the target.

Table I Capacity addition (MW) in the first four years of the Ninth Plan

Year	*Central*	*State*	*Private*	*Total*
1997/98	333.0	1676.0	1217.5	3226.5
1998/99	991.6	1675.4	1575.0	4242.0
1999/2000	1615.4	2329.1	563.0	4507.5
2000/01	659.0	2297.0	819.7	3775.7
Total	3599.0	7977.5	4175.2	15751.7

Source Planning Commission (2001)

Plant load factor

The annual all-India PLF of thermal stations during 2000/01 was 69%, which was 2.3% more than the target of 66.7% for the same period. The improvements in the overall PLF of the state and central sector stations during the past five years is shown in Table II.

Table II Annual plant load factors of central and state sector stations (%)

Year	*Centre*	*State*	*Overall*
1995/96	71.0	60.3	64.4
1996/97	71.1	60.3	64.4
1997/98	70.4	60.9	64.7
1998/99	71.1	60.1	64.6
1999/2000	73.8	63.7	67.3
2000/01	74.3	65.6	69.0

Source MoP (2000/01) and data obtained from the Central Electricity Authority.

Central sector stations operated at a PLF of over 70% whereas the state sector stations operated at 60% to 65%. However, large inter-state variations exist. For example, in Assam, Bihar, Delhi, and West Bengal the average PLF is below 40%, whereas states from the south and west have a PLF greater than 70% (Table 1.66). Low quality of coal, age of the plants, and low load in the regions may be the reasons for the low PLF in some states.

Captive capacity

The industrial sector is the largest consumer of electricity. Besides purchasing power from utilities a number of industries such as the aluminium, cement, fertilizer, iron, steel, paper, and sugar have established their own captive power plants. These plants are intended to supplement the electricity purchased, for emergency use in case of power cuts, for producing energy as a by-product of industrial process. As per the CEA, the all-India installed capacity of non-utility power of capacity greater than 1 MW was 9168 MW during 1991/92. This capacity increased to 13 003 MW and yielded a generation of about 44 billion units in 1997/98 (Table 1.68). From 1991/92 to 1997/98, the increase in captive capacity was between 2% and 9%, with the highest in 1997/98 and lowest in 1996/97. According to news reports, the captive capacity exceeds 20 000 MW in the country (Map 1).

Demand projections

A realistic assessment of energy and peak power requirements is vital for planning and operation of the electricity system in India. According to the 16th EPS (Electric Power Survey), the all-India peak demand will be about 85 132, 115 705, 157 107, and 212 725 MW by the end of the Ninth (2001/02), Tenth (2006/07), Eleventh (2011/12) and Twelfth (2016/17) Five-year Plans, respectively. The corresponding energy requirements are 529 013, 719 097, 975 222, and 1 318 644 MU, respectively. Compared to the 15th EPS projections, these are less by about 11% in peak demand and 7% to 8% in energy requirement.

Transmission and distribution

With the evolution of the national power grid, the inter-regional transfer capacity increased to 4350 MW in 2000/01 from 1200 MW in 1996/97. There was a substantial increase in energy exchange among the regions to 9874 MU in 2000/01 from 5092 MU in 1997/98 (Map 2).

As seen from Figure 1, bulk of this exchange (about 50% in 1997/98 and 1998/99, 67% in 1999/2000, and 73% in 2000/01) has been drawn mainly from the surplus of the eastern region to the other regions.

The growth of the T&D network has increased the number of towns and villages that have access

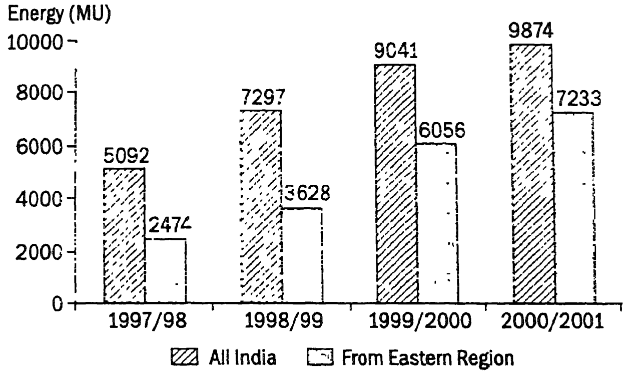


Figure 1 Inter-regional energy exchange among the region
Source MoP. 3 March 2001. Agenda Notes. Power Ministers' Conference; data obtained from the CEA

to power. Electrification of about 0.5 million villages and energization of 11.8 million pump-sets have been completed besides electrifying all towns and cities. As compared with the previous year, there exists an increase of 7.4% in the T&D network, 0.6% in electrification of villages and 2.4% in energization of pump-sets (Table 1.79).

Transmission and distribution losses

Over the years, the SEBs have under-reported T&D losses, which have been revealed after the initiation of a realistic assessment of T&D losses in the states undergoing reforms. In some states, these losses have been estimated to be over 40%—unheard of in the past. For example, in Orissa, Andhra Pradesh, Haryana and Rajasthan, the T&D losses are estimated to be 51%, 45%, 47%, and 43%, respectively, as against the reported losses of 23%, 25%, 32%, and 26%, respectively before restructuring. Inadequate investments on T&D facilities, particularly sub-transmission and distribution, and lack of proper distribution planning are the major factors that have contributed to the high technical losses in the system. In addition, defective metering, unmetered supply, and pilferage have resulted in high non-technical losses rampant in most states.

Investments

Overall improvements in the power sector call for greater investments in generation and in the T&D network. Till the early 1990s, the government was solely responsible for investments in the power sector. In view of the growing demand for supply of power, the government has realized that only its own investments are not sufficient to meet the requirement. The government has, therefore, decided to invite private sector participation in generation and later on in T&D while liberalizing its policies. As a result, the plan outlay for the power sector decreased from 18.4% in the Eighth Plan to 14.25% in the Ninth Plan.

Private sector participation

Since the liberalization process started in 1991, 25 private power projects have been commissioned till 31 January 2001, with an installed capacity of 5370 MW (Table 1.100). The PFC (Power Finance Corporation) has provided assistance of 42 136 million rupees besides providing guarantees worth about 13 415 million rupees to 23 private power projects (MoP 2001b). Table III provides the status of private power projects as on 31 January 2001.

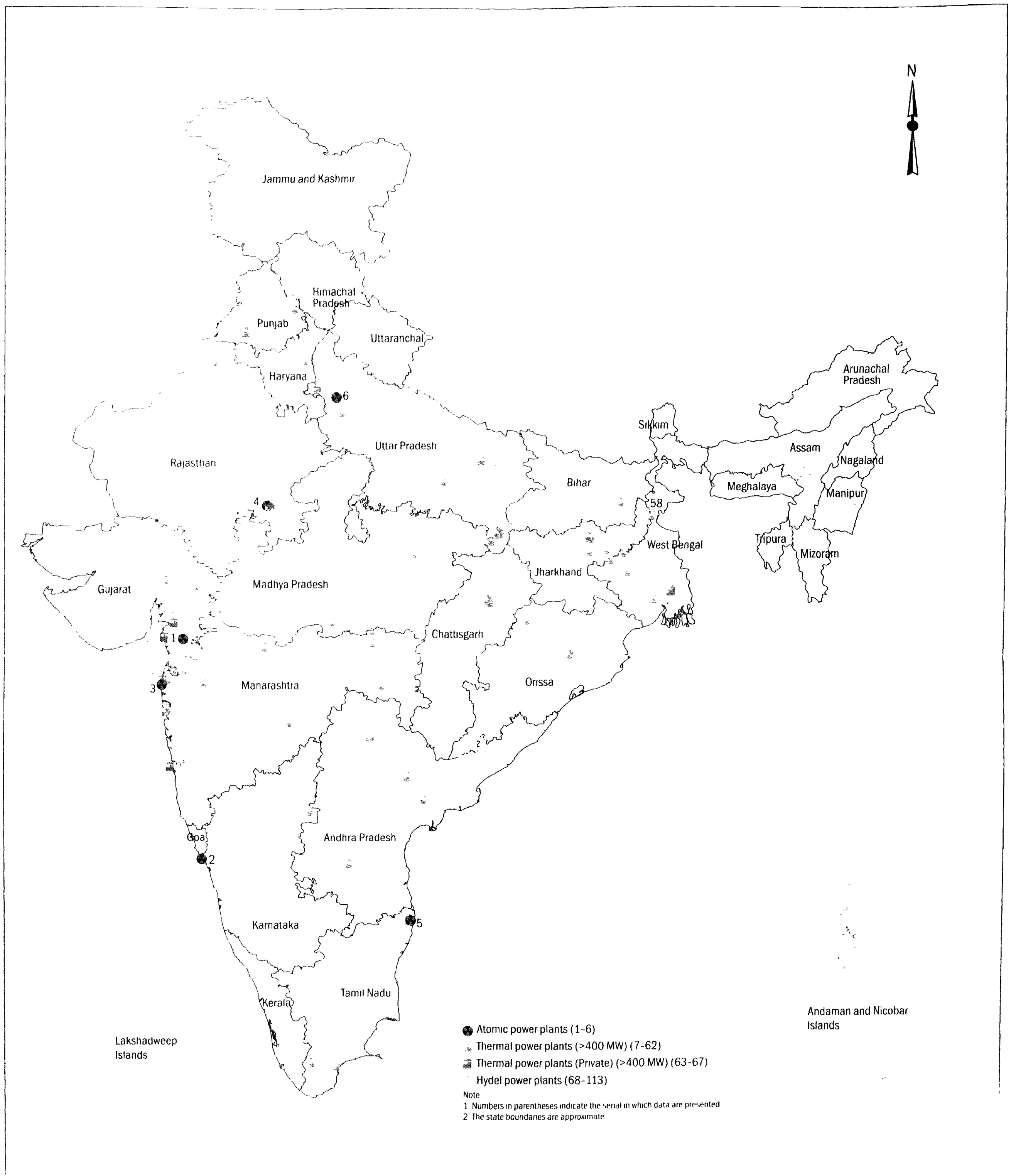
Table III Status of PPPs (private power projects) as on 31 January 2001

Description	*Number*	*Capacity* (MW)
Projects with techno-economic clearance from the Central Electricity Authority	57	29 375
PPPs commissioned till 31 January 2001	25	5 370
PPPs under construction	17	5 149

Source MoP (2001b)

During the Ninth Plan, a capacity addition of 17 588 MW from the private sector was planned. As per the mid-term appraisal, conducted in July 1999, the capacity was scaled down to 8363 MW. As per the review conducted by the MoP in August 2000, only 6735 MW appears to be feasible by the end of the Ninth Plan. The details of these identified projects in the private sector are given in Table 1.101. The capacity addition achieved during the first four years of the Ninth Plan was 4702.5 MW, with an additional 1347 MW in 2000/01.

Following the issuance of policy guidelines for private sector investment in transmission in 1998, Power Grid (Central Transmission Utility) has identified a number of transmission projects involving an investment of about 120 520 million rupees to be set up entirely by the private sector. These are part of the transmission projects associated with evacuation of power from the power projects of Rihad Stage II, Maithon Right Bank, Ennore, Karcham Wangtoo, Kahalgaon Stage II, Barh, and North Karanpura. These projects will be taken up at 400-kV capacity. Power Grid has already floated the tenders for these, and the winning bidders are required to set up independent power transmission companies to take up the projects. These projects are likely to be commissioned in the Tenth and Eleventh Plans. Power Grid is also trying to increase private participation in transmission projects through joint ventures. The private sector is expected to acquire a 26% stake in these projects. The first joint venture transmission project has been identified to evacuate power from the Tala HE project in Bhutan. At the state level, the governments of



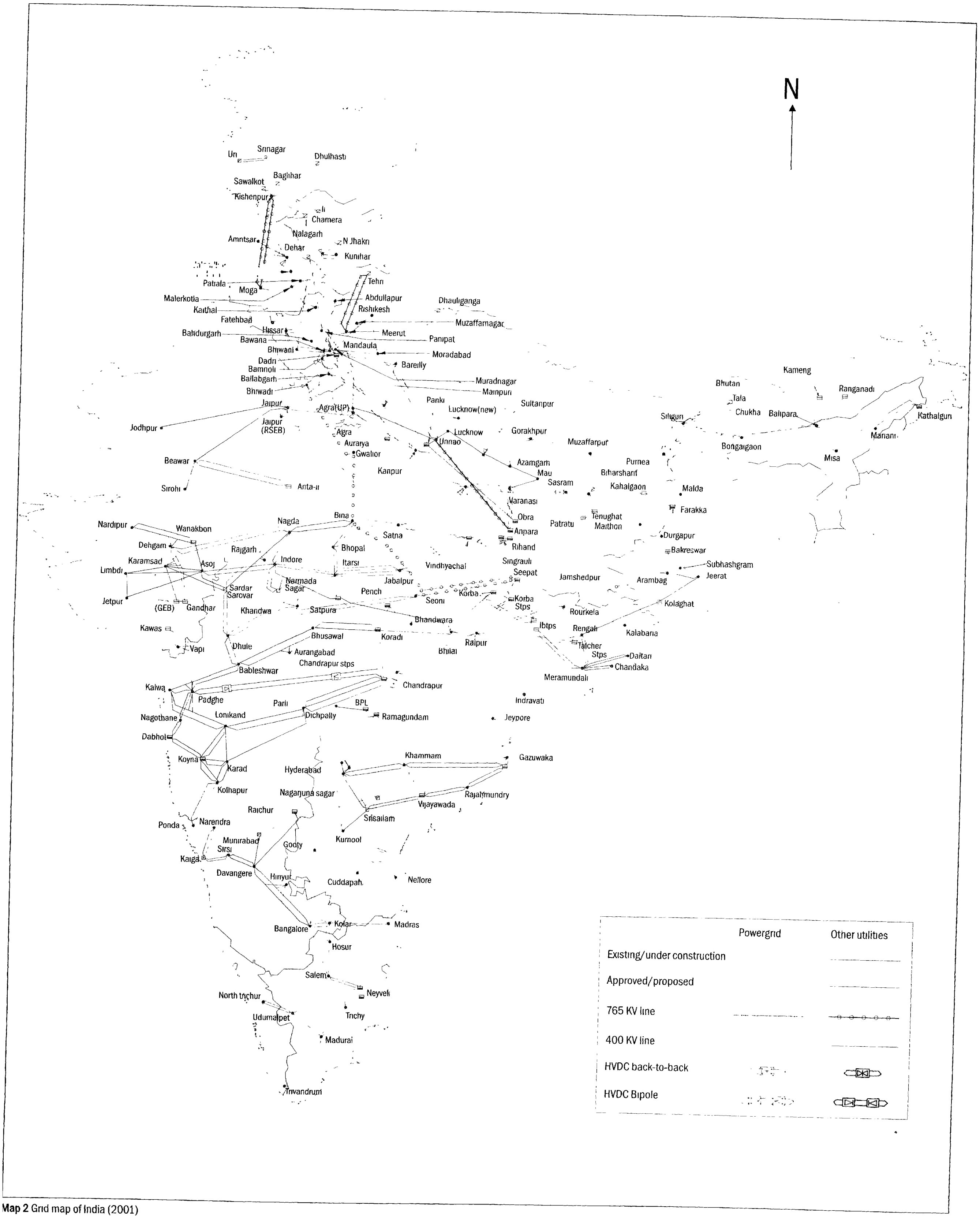
Note
1 Numbers in parentheses indicate the serial in which data are presented
2 The state boundaries are approximate

Map 1 Major power generating units of India (December 2001)

Sources

1 Survey of India Dehra Dun
2 Central Electricity Authority New Delhi
3 Central Board for Irrigation and power New Delhi

Facing page no 110



Map 2 Grid map of India (2001)

ource

owergrid Corporation of India, New Delhi (2001)

acing page no. 111

Map 1 Major power generating units of India

Sl. no	Location	Capacity (MW)	Operator
Nuclear power plants			
1	Kakrapar, Gujarat	440	–
2	Kaiga, Karnataka	440	–
3	Tarapur, Maharashtra	320	–
4	RAPS, Rajasthan	740	–
5	Kalpakkam, Tamil Nadu	340	–
6	Narora, Uttar Pradesh	440	–
Thermal power plants			
7	Kothagudem TPS, Andhra Pradesh	1180	APSEB
8	Ramagundam STPS, Andhra Pradesh	2100	NTPC
9	Rayalaseema TPS, Andhra Pradesh	420	APSEB
10	Vijayawada TPS, Andhra Pradesh	1260	APSEB
11	Kahalgaon STPP, Bihar	840	NTPC
12	Birsinghpur TPS, Chattisgarh	840	MPEB
13	Korba West TPS, Chattisgarh	840	MPEB
14	Korba East TPS, Chattisgarh	440	MPEB
15	Korba STPS, Chattisgarh	2100	NTPC
16	Badarpur TPS, Delhi	720	NTPC
17	Gandhinagar, Gujarat	870	GEB
18	Ukai TPS, Gujarat	850	GEB
19	Wanakbori STPP, Gujarat	1470	GEB
20	Panipat TPS, Haryana	860	HSEB
21	Bokaro 'A+B' TPS, Jharkhand	877.5	DVC
22	Chandrapura TPS, Jharkhand	780	DVC
23	Patratu TPS, Jharkhand	840	BSEB
24	Tenughat TPS, Jharkhand	840	TVNL/TNPCL
25	Raichur TPS, Karnataka	1260	KPCL
26	Satpura TPS, Madhya Pradesh	1142.5	MPEB
27	Bhusaval TPS, Maharashtra	482.5	MSEB
28	Chandrapur TPS, Maharashtra	2340	MSEB
29	Dahanu TPS, Maharashtra	500	TEC
30	Khaperkheda TPS, Maharashtra	840	MSEB
31	Koradi TPS, Maharashtra	1100	MSEB
32	Nasik TPS, Maharashtra	910	MSEB
33	Parli TPS, Maharashtra	690	MSEB
34	Trombay TPS, Maharashtra	1337.5	TEC
35	IB Valley TPS, Orissa	420	OPGC
36	Talcher STPP, Orissa	1000	NTPC
37	Talcher TPS, Orissa	470	NTPC
38	GHTP (Bhatinda) TPS, Punjab	420	PSEB
39	GNDTP (Bhatinda) TPS, Punjab	650	PSEB
40	Ropar TPS, Punjab	1260	PSEB
41	Kota TPS, Rajasthan	850	RSEB
42	Suratgarh TPS, Rajasthan	750	RSEB
43	Ennore TPS, Tamil Nadu	450	TNEB
44	Mettur TPS, Tamil Nadu	840	TNEB
45	North Madras TPS, Tamil Nadu	630	TNEB
46	Tuticorin TPS, Tamil Nadu	1050	TNEB
47	Anpara 'B' TPS, Uttar Pradesh	1630	UPSEB
48	Feroz Gandhi Unchahar TPP, Uttar Pradesh	840	NTPC
49	Harduaganj 'C' TPS, Uttar Pradesh	540	UPSEB
50	National Capital TPP, Uttar Pradesh	840	NTPC
51	Obra TPS, Uttar Pradesh	1550	UPSEB
52	Tanda TPS, Uttar Pradesh	440	NTPC
53	Rihand STPS, Uttar Pradesh/ Madhya Pradesh	1000	NTPC
54	Singrauli STPS, Uttar Pradesh/ Madhya Pradesh	2000	NTPC
55	Vindhyachal STPP, Uttar Pradesh/ Madhya Pradesh	2260	NTPC
56	Bandel TPS, West Bengal	540	WBSEB
57	Budge Budge, West Bengal	500	CESC
58	Farakka STPP, West Bengal	1600	NTPC
59	Kolaghat TPS, West Bengal	1260	WBPDC
60	Mejia TPS, West Bengal	630	DVC
61	Santhaldih TPS, West Bengal	480	DVC
62	Bakreswar TPS, West Bengal	420	WBPDCL
Private power plants			
63	Hazira, Gujarat	515	–
64	Paguthan, Gujarat	655	–
65	Dabhol, Maharashtra	740	–
66	Dahanu, Maharashtra	500	–
67	Budge-Budge, West Bengal	500	–
Hydel power plants			
68	Nagarjuna, Andhra Pradesh	960	–
69	Sileru, Andhra Pradesh	580	–
70	Srisailam, Andhra Pradesh	770	–
71	Kopili, Assam	100	–
72	Hansdeo Bango, Chattisgarh	120	–
73	Khodri, Chattisgarh	120	–
74	Kadana, Gujarat	120	–
75	Ukai, Gujarat	305	–
76	Baira Siul, Himachal Pradesh	180	–
77	Chamera, Himachal Pradesh	540	–
78	Dehar, Himachal Pradesh	990	–
79	Pong, Himachal Pradesh	360	–
80	Sanjay, Himachal Pradesh	120	–
81	Shanan, Himachal Pradesh	110	–
82	Lower Jhelum, Jammu and Kashmir	105	–
83	Salal, Jammu and Kashmir	460	–
84	Jog, Karnataka	120	–
85	Kalinadi, Karnataka	810	–
86	Sharavathy, Karnataka	891	–
87	Supa, Karnataka	100	–
88	Varahi, Karnataka	230	–
89	Idukki, Kerala	780	–
90	Sabaragiri, Kerala	300	–
91	Bansagar, Madhya Pradesh	315	–
92	Gandhi Sagar, Madhya Pradesh	115	–
93	Pench, Madhya Pradesh	160	–
94	Bhira, Maharashtra	282	–
95	Koyna, Maharashtra	920	–
96	Loktak, Manipur	105	–
97	Balimela, Orissa	360	–
98	Hirakud, Orissa	306	–
99	Machgund, Orissa	114.75	–
100	Rengali, Orissa	250	–
101	Upper Kolab, Orissa	320	–
102	A.P.Sahib, Punjab	134	–
103	Bhakra, Punjab	1100	–
104	Mukerian, Punjab	195	–
105	Rana Pratap, Rajasthan	172	–
106	Kadamparai, Tamil Nadu	400	–
107	Kundah, Tamil Nadu	555	–
108	Mettur, Tamil Nadu	240	–
109	Rihand, Uttar Pradesh	300	–
110	Chibro, Uttaranchal	240	–
111	Chilla, Uttaranchal	144	–
112	Ramganga, Uttaranchal	198	–
113	Tanakpur, Uttaranchal	120	–

APSEB - Andhra Pradesh State Electricity Board
BSEB - Bihar State Electricity Board
DVC - Damodar Valley Corporation
GEB - Gujarat Electricity Board
HSEB - Haryana State Electricity Board
KPCL - Karnataka Power Corporation Ltd
NTPC - National Thermal Power Corporation
MPEB - Madhya Pradesh Electricity Board
MSEB - Maharashtra State Electricity Board
OPGC - Orissa Power Grid Corporation
PSEB - Punjab State Electricity Board
RSEB - Rajasthan State Electricity Board
TEC - Tata Electric Companies
TNEB - Tamil Nadu Electricity Board
TNPCL - Tamil Nadu Power Corporation Ltd
TPS - Thermal Power Station
TVNL - Tenughat Vidyut Nigam Ltd
UPSEB - Uttar Pradesh State Electricity Board
WBPDC - West Bengal Power Development Corporation
WBSEB - West Bengal State Electricity Board

Karnataka and Madhya Pradesh too had identified several transmission projects and had also invited private sector participation in these. Not much progress has been shown since.

Private sector participation in distribution is expected to fetch not only much-needed investments, but also improvements in the overall efficiency of the system. Till date, Orissa is the only state that has achieved complete privatization of distribution. A few other states (Andhra Pradesh, Delhi, Haryana, Karnataka, and Uttar Pradesh) are also planning to privatize their distribution system.

Power sector reforms

One-time settlement of SEB dues

In a significant move, the MoP has set up an expert group to recommend a one-time settlement of SEB dues to encourage and speed up power sector reforms in the states. Although some states have restructured SEBs, others still continue with the existing system. Massive dues of 260 000 million rupees (till October 2000) are owed to CPSUs (central public sector units) such as the NTPC (National Thermal Power Corporation Ltd), the NHPC (National Hydroelectric Power Corporation Ltd), and Coal India Ltd from the SEBs. Keeping this in mind, the ministry has decided to offer a scheme of one-time settlement of SEB dues by issuing bonds.

Important orders issued by CERC

Since its inception, the CERC (Central Electricity Regulatory Commission) has issued several orders relevant to the central sector utilities in generation and transmission. In general, the Commission has issued an order for Grid code to pave the way for a smoother and better operation of the national grid and an order for ABT (availability-based tariff) for the central generating companies. Subsequently, the Commission had stayed the ABT order following the filing of a review petition by the NTPC. Meanwhile, it also filed an appeal against the order in the Delhi High Court. However, in 2000/01, the Commission has issued an ABT review order for implementation. The Commission has also issued an order for regulation of power supply to central utilities and tariff norms for central generating stations and norms for interstate transmission.

ABT review order

According to the ABT review order, the Commission has found that there are no errors in the ABT order that was issued in January 2000. In the review order, the Commission has removed its stay on implementation of the ABT order while revising the dates for implementation of the order. As per the ABT review order, the revised dates for implementation are as follows: Southern Region on 1 April 2001, Eastern Region on 1 May 2001, Northern Region on 1 June 2001, and Western Region on 1 August 2001.

Status of reforms

Of the state governments already in the path of reform and restructuring since the early 1990s, the reform process in Orissa has gone farthest with privatization of distribution in the state. The vertically integrated monopoly business being unbundled, the sector development as well as functions are being overseen by regulatory commissions being established under the central or the state Reform Act. Currently, as many as 15[1] states have constituted their SERCs[2] besides the CERC and 11[3] of them have issued at least their first tariff order.

The generation business has been the first to witness private participation. As has been chronicled repeatedly, the policy makers, in a bid to mobilize the much-needed investments and promote competition in a financially constrained and inefficiency riddled sector, invited private bids in the generation business in 1991 through a resolution passed by the Ministry of Power and Non-Conventional Energy Sources (Department of Power) in October 1991. In spite of the initial euphoric response to the privatization policy in terms of expressing interest and submission of proposals, only a few projects have been ultimately commissioned as evident from Table III. The reasons for the same are many, but two of the most critical ones are lack of investor confidence and bureaucratic delays. The current Draft Bill

---

[1] Andhra Pradesh, Arunachal Pradesh, Delhi, Gujarat, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.

[2] www.cercind.org.in

[3] Andhra Pradesh, Delhi, Gujarat, Haryana, Himachal Pradesh, Karnataka, Maharashtra, Orissa, Rajasthan, Tamil Nadu and Uttar Pradesh.

2001, however, attempts to facilitate the investment process by allowing establishment, operation and maintenance of generating plants without obtaining license as long as the technical standards related to connectivity with grid are maintained. Thus the Bill envisages a power market where the generator has the option of selling electricity to any licensee, thereby promoting the concept of 'open access'.

As far as unbundling of business is concerned, many of the reforming states have unbundled their business to form separate generation companies. These companies either oversee both the hydro and thermal plants or at times are separated out where some have separate companies catering to hydro plants and thermal plants (Box 1). The transmission businesses are also unbundled into separate companies or along with the distribution

Box 1 Summary of the electricity sector unbundling in different states

Uttar Pradesh	
Generation companies	UPRVUNL (Uttar Pradesh Rajya Vidyut Utpadhan Nigam Ltd) (Thermal) UPJVNL (Uttar Pradesh Jal Vidyut Nigam Ltd) (Hydro)
Distribution companies	UPPCL (Uttar Pradesh Power Corporation Ltd) (both transmission and distribution company), KESCO (Kanpur Elelctricity Supply Company Ltd), NPCL (Noida Power Company Ltd)
Orissa	
Generation companies	OHPC (Orissa Hydro Power Corporation) Ltd OPGC (Orissa Power Generarion Corporation) Ltd
Transmission company	GENCO (Generation Company Ltd)
Distribution companies (privatized)	WESCO (Western Electricity Supply Company of Orissa Ltd), NESCO (North-Eastern Electricity Supply Company of Orissa Ltd), CESCO (Central Electricity Supply Company of Orissa Ltd), SOUTHCO (Southern Electricity Supply Company of Orissa Ltd)
Andhra Pradesh	
Generation company	APGENCO (Andhra Pradesh Generation Corporatrion) Ltd (both hydel and thermal plants come under this company)
Transmission company	APTRANSCO (Transmission Corporation of Andhra Pradesh Ltd)
Distribution companies	APEPDCL (Eastern Power Distribution Company of Andhra Pradesh Ltd), APCPDCL (Central Power Distribution Company of Andhra Pradesh Ltd), APNPDCL (Northern Power Distribution Company of Andhra Pradesh Ltd), APSPDCL (Southern Power Distribution Company of Andhra Pradesh Ltd)
Rajasthan	
Generation company	RVUN (Rajasthan Vidyut Utpadan Nigam)
Transmission company	RRVPN (Rajasthan Rajya Vidyut Prasaran Nigam) Ltd
Distribution companies	AVVNL (Ajmer Vidyut Vitran Nigam Ltd), JVVNL (Jaipur Vidyut Vitran Nigam Ltd), JDVVNL (Jodhpur Vidyut Vitran Nigam Ltd)
Haryana	
Generation company	HPGCL (Haryana Power Generation Corporation Ltd) (both hydel and thermal plants come under this company)
Transmission company	HVPNL (Haryana Vidyut Prasaran Nigam Ltd)
Distribution companies	UHBVNL (Uttar Haryana Bijli Vitaran Nigam Limited), DHBVNL (Dakshin Haryana Bijli Vitaran Nigam Ltd)
Delhi	
Generation company	Indraprastha Thermal Power Generation Company Ltd (Genco)
Transmission company	Delhi Power Supply Company Ltd (Transco)
Distribution companies	C-EDEDCL (Central East Delhi Electricity Distribution Company Ltd), S-WDEDCL (South West Delhi Electricity Distribution Company Ltd), N-NWDEDCL (North North-West Delhi Electricity Distribution Company Ltd)

company they form a single entity. But the transmission business is yet to witness private players.

Currently the focus is on the distribution company, with policy-makers and experts recognizing that reforms in the distribution segment holds the key for the success of the entire reform programme. Orissa, the first state to embark on a massive restructuring programme, is currently the only state with private distribution companies. Though the Orissa model has been a pioneer in the electricity restructuring exercise in India, it has come under severe criticism in recent times; the Ahluwalia Committee Report (July 2001) criticized its single-buyer model. However, the same model is still being followed in Andhra Pradesh and Haryana, but Gujarat, Tamil Nadu and Kerala have adopted an alternative path where they defined distribution circles in the initial stage, which are supposed to function as profit centres with full autonomy. The recent development on the distribution privatization exercise has been the initiative taken by the Delhi government with respect to the Delhi Vidyut Board. The private bidders in this case will be selected on the basis of their loss reduction/efficiency improvement bids. Moreover, the directive also proposes sharing of gains (if any) achieved through better performance of the service provider with consumers.

Tariff reform

The ERCs (electricity regulatory commissions) have started functioning at the centre and in 12 states. The SERCs of Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Orissa, Rajasthan, and Uttar Pradesh have issued tariff orders in 2000/01.

In the process of tariff setting, transparency was brought into tariff fixation, which was traditionally a closed-door exercise. The ERCs have instituted measures to allocate revenue requirement in an economically efficient manner by reducing the extent of cross-subsidies. This has primarily been achieved by increasing the low-tension tariff to a greater extent as compared to high-tension tariff. The increase in the agricultural tariff, which is the most politicized tariff category, is a bold measure initiated by a number of ERCs. In some states, this has not been passed on to the consumers because the government has agreed to offer a subsidy to compensate the utilities. However, to encourage metering in the agriculture sector, the rise is moderated in the metered tariff.

In the process of tariff setting, the commissions have had to face various issues such as quality of supply, energy auditing, and transformer failure. In this regard, the commissions have issued directions to the utilities along with the tariff orders, and these issues are closely related.

Policy and development

Accelerated Power Development Programme

In 2000/01, the Union Government approved the new APDP scheme. The programme envisages improvement in the performance of the generating stations and reduction in T&D losses. The programme provides full project costs to special-category states like Jammu and Kashmir, Himachal Pradesh, and constituents of north-eastern states in a grants:loan ratio of 90:10 while providing 50% of the project costs in a grants:loan ratio of 50:50 to other states. A priority for allocation of funds will be accorded to states that undertake a time-bound programme for power sector reforms. The scheme is likely to continue till the end of the Eleventh Plan.

For 2000/01, the outlay allocated was 5372.2 million rupees. In the first phase, 60 distribution circles have been identified from 16 states for the upgradation of the sub-transmission and distribution network, including energy accounting by improved metering. The remaining distribution circles in the country will be covered in a phased manner, as funds become available under the programme.

For 2001/02, the programme outlay has been allocated 15 000 million rupees.

Liquid fuel policy

In partial modification of the Liquid Fuel Policy, 1998 (where all other fuels except naphtha were taken out of the ceiling limit of 12 000 MW), HSD (high-speed diesel), distillate oil 2, and LDO (light diesel oil) have also been allowed to be used as primary fuels for power generation with effect from 19 January 2001.

Enhancement of the CEA limit for captive/cogeneration plants

The limit on capital expenditure of schemes, exceeding which concurrence of the CEA is required, has been amended from time to time.

Extending the last enhancement of CEA limits notified in 1999, captive plants set up by generation companies and having a capital cost of up to 30 000 million rupees, have been exempted from the requirement of CEA's TEC (techno-economic clearance), provided that at least 50% of the installed capacity will be used for captive/group captive consumption.

Power trading

The PTC (Power Trading Corporation of India Ltd) was established in 1999 primarily to facilitate the MPPs (mega power projects) in the private sector. Under long-term arrangements, the PTC will act as a single entity to enter into PPAs (power purchase agreements) with IPPs (independent power producers) and multipartite/ multilayer PPAs with the users/SEBs. Thus, the arrangement not only insulates against the risk of receivables, but also insulates mega-IPPs from the protracted negotiations with multipartite/ SEBs. Till date, the corporation has traded around 71.5 MU between the SEBs: the PSEB (Punjab State Electricity Board) to the GEB (Gujarat Electricity Board) and the MSEB (Maharashtra State Electricity Board) to the KEB (Karnataka Electricity Board), which later became the KPTCL (Karnataka Power Transmission Corporation Ltd). Being a nodal agency within India, the PTC has also been nominated as a nodal agency for Indo-Nepal power exchange. For the future, the Corporation has signed PPAs with the WBPDCL (West Bengal Power Development Corporation Ltd) and also with the users of the HVPNL and the DVB. In addition, the users of all SEBs have signed PPA/MoU with the Corporation for buying Chukka power from Bhutan. In the near future, the corporation is also likely to deal with the neighbouring SAARC (South Asian Association for Regional Cooperation) countries after the establishment of the SAARC grid.

Resolutions

At the Power Ministers' Conference held on 3 March 2001, a number of resolutions were put forth to the states regarding the power sector.

- Complete rural electrification by the end of the Tenth Plan, i.e. by 2007.
- Conduct compulsory energy auditing at all 11-kV feeders to be made effective within six months. An effective MIS (management information system) needs to be made operational.
- Carry out 100% metering of all consumers by December 2001.
- Improve quality of supply through APDP and other programmes, particularly in rural areas.
- Make the distribution sector commercially viable in two to three years by creating profit centres that are fully accountable, by the privatization of distribution, and the handing over of local distribution to *Panchayats*, local bodies, franchisees, or user associations.
- Focus on private investments in the distribution sector.
- Reach a break-even point in current operations in distribution and achieve positive returns thereafter.
- Make the SERCs functional within six months and file tariffs.
- Give subsidies only till the state governments can pay explicitly through budgetary provisions.
- Implement minimum agricultural tariff of 50 paise per kilowatt-hour to move away from the regime of providing free supply.
- Link support of the Union Government to the time-bound power sector reform initiatives in the states and restore the financial health of utilities.
- Set up an expert group to recommend one-time settlement of dues to the CPSUs.

Commercial aspects

Rate of return of SEBs

As per section 59 of the Electricity (Supply) Act, 1948, SEBs are required to earn a minimum of 3% RoR (rate of return) on their net fixed assets in service after providing depreciation and interest charges. However, due to low tariff and the operational inefficiencies of SEBs, most of them are unable to comply with this stipulation. In 2000/01, none of the SEBs had a positive RoR either without subsidy (Table 1.96) or with subsidy (Table 1.95). In comparison to 1995/96, 10 of 19 SEBs had a positive RoR (with subsidy) when the all-India average RoR stood at –2.2%. Thereafter, the average RoR (with subsidy) for SEBs decreased to as low as –26.34% in 1999/ 2000 and was –27.13% in 2000/01 (Table 1.95). The average RoR (without subsidy) for SEBs during 1992/93 was –12.7%. This has dropped to a low of –33.78% in 1999/2000 and –35% in 2000/01 (Table 1.96).

System improvement and capacity addition in the state sector has been greatly affected by the operational inefficiency and poor financial performance of the SEBs.

Retail tariff of SEBs

Due to several reasons, many of the SEBs were unable to charge their consumers even at the cost of supply. The tariff fluctuates widely between states and between consumer categories (Table 1.83). The major consumer categories are domestic, agricultural, commercial, industrial, and railway traction. The average tariff for the domestic and agricultural consumers is less than the average cost of supply whereas that for commercial, industrial, and railway traction categories is more than the average cost of supply (Tables 1.82 and 1.83).

During 2000/01, the all-India average tariff for SEBs was 212 paise/kWh. In the corresponding year, out of 19 SEBs, 10 SEBs were below the average tariff (Table 1.84). The average tariff has increased from 105 paise/kWh (1992/93) to 212 paise/kWh (2000/01) in comparison with the average cost of supply, which increased from 128 paise/kWh (1992/93) to 303.8 paise/kWh (2000/01) (Tables 1.82 and 1.84).

In terms of the percentage of cost incurred, the sales revenue has decreased by 0.4% from 1999/2000 to 2000/01. The ratio of sales revenue to the cost of supply during 1999/2000 was 70%. However, this ratio was particularly low in Andhra Pradesh, Bihar, and Jammu and Kashmir. In addition, this ratio was below the average value in eight other states (Table 1.90).

As a percentage of sales revenue, the revenue arrears has increased from 29.8% in 1994/95 to 36.4% during 1995/96 and was 33.8% in 1997/98. At any point of time, the arrears are equivalent to a locking up of four months of revenue with the consumers. As on 1997/98, in comparison with inter-state variations in Bihar, Jammu and Kashmir, and Kerala, Meghalaya have outstanding dues that are more than 100% of their annual sales revenue whereas Tamil Nadu has the lowest of 1.9% (Table 1.85).

Effective subsidy and cross-subsidization

The amount of subsidy provided to sectors such as domestic and agricultural has increased from 202 099 million rupees in 1996/97 to 330 814 million rupees in 1999/2000. The estimated amount of subsidy in 2000/01 was 370 371 million rupees. During 1997/98, about 77% of the subsidy was provided to the agricultural sector. Due to the introduction of a minimum agricultural tariff of 50 paise/unit in some states, there was a slight reduction in subsidy of about three per cent in 1999/2000 and four per cent in 2000/01.

A substantial gap exists between the subsidy provided to the agricultural and domestic sectors and the total inflow on account of compensation provided by the state governments and cross-subsidy from industrial and commercial sectors. While some state governments partly provide a compensation for subsidy, others do not provide any compensation.

The annual commercial losses of SEBs, excluding the state government subsidy, were 45 600 to 87700 million rupees from 1992/93 to 1995/96. Subsequently, these losses have increased steadily from 84 740 million rupees in 1996/97 to 260 130 million rupees in 2000/01.

Cross-subsidy as a percentage of the subsidy was 37% to 42% from 1992/93 to 1999/2000 (Tables 1.86–1.88). The level of cross-subsidization provided by the industrial and commercial sectors can have an adverse impact on the competitiveness of these sectors. This can also encourage them to set up their own captive generation.

References

MoP (Ministry of Power). 2001a
2001: Annual report
New Delhi: MoP, Government of India

MoP (Ministry of Power). 2001b
www.powermin.nic.in
[accessed on 29 May 2001]

Planning Commission. 2001
Annual Report on Working of State Electricity Boards and Electricity Departments.
New Delhi: Planning Commission, Government of India.

Table 1.61 Power scenario in India

State / Union Territory	*Surplus (+)/deficit (–) (%) energy* *1991/92 (beginning of Eighth Plan)*	*1996/97 (End of Eighth Plan)*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[a]	*Peak surplus (+)/deficit (–) (%) energy* *1991/92 (beginning of Eighth Plan)*	*1996/97 (End of Eighth Plan)*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[a]
State												
Andhra Pradesh	-6.7	-22.1	-14.4	-8.7	-6.6	-7.8	-15.8	-23.6	-11.3	-9.3	-11.7	-14.6
Assam	–	-10.2	-8.7	-2.7	1.7	7.8	–	0	-5.7	-3.2	-1.6	-0.9
Bihar	-29.7	-27.5	-19.9	-8.1	-6.3	-7.0	-43.7	-48.4	-41.2	-15.4	-16.0	-14.1
Delhi	-1.0	-2.6	-1.9	-1.9	-0.5	-4.9	-8.0	-7.0	-6.8	-8.1	-12.4	-13.3
Goa	0	0	0	-12.4	-21.7	-10.8	-18.8	-8.0	–	-19.2	-10.0	-9.8
Gujarat	-4.3	-8.1	-5.3	-6.2	-8.2	-9.7	-18.3	-15.6	-6.4	-16.3	-21.1	-11.5
Haryana	-2.0	-5.9	-1.6	-2.1	-2.3	-2.8	-20.2	-15.9	0	-8.3	0	-3.3
Himachal Pradesh	-0.7	-0.9	-0.1	-0.2	-0.3	-3.2	-21.9	0	0	0	0	0
Jammu and Kashmir	-10.8	-10.0	-2.7	-6.0	-9.2	-16.4	-31.3	-17.1	-3.7	-18.2	-17.0	-16.8
Karnataka	-23.6	-27.1	-20.3	-13.2	-8.3	-9.1	-28.5	-28.5	-27.5	-15.5	-15.5	-13.2
Kerala	-3.3	-22.7	-19.0	-9.7	-7.3	-6.6	-18.3	-24.0	-26.4	-11.6	-9.1	-5.1
Madhya Pradesh	-5.6	-12.0	-6.7	-5.8	-7.1	-12.4	-21.3	-29.1	-17.2	-25.2	-29.7	-25.3
Maharashtra	-4.5	-5.6	-2.9	-3.9	-6.1	-10.5	-8.7	-8.7	-9.4	-18.7	-19.3	-15.5
Meghalaya	–	0	3.1	5.7	5.2	7.3	–	0	-4.2	1.0	1.6	0
Orissa	-7.0	-3.0	-1.8	3.3	2.8	3.1	-23.9	-13.8	-8.4	-2.0	-5.2	2.2
Punjab	-6.2	-1.6	-0.8	-2.2	-0.6	-2.7	-11.1	-8.1	0	0	0	-2.0
Rajasthan	-1.4	-7.4	-1.8	-2.5	-4.5	-3.6	-5.8	-5.6	-0.9	-4.2	0	-2.5
Tamil Nadu	-4.8	-13.8	-14.1	-11.8	-7.9	-7.6	-16.7	-15.9	-19.7	-12.8	-12.5	-15.3
Uttar Pradesh	-10.3	-13.9	-12.3	-9.8	-12.9	-14.6	-17.8	-20.0	-24.6	-19.8	-23.1	-15
West Bengal	-9.0	-2.9	0.7	2.8	1.9	0.9	-31.2	-11.1	-7.0	-5.8	-6.4	-4.7
Union Territory												
Arunachal Pradesh	–	-48.5	-20.1	-8.7	0.8	1.9	–	-21.6	-14.9	-2.0	-6.3	0
Manipur	–	-10.7	-20.9	-1.1	-4.1	-2.3	–	-21.8	-15.5	-3.1	4.0	3.3
Mizoram	–	-19.2	-20.8	-5.1	1.4	2.7	–	0	-10.8	-5.2	0	-2.7
Nagaland	–	-16.1	-25.4	-4.8	1.1	2.6	–	7.1	-23.5	-16.7	-2.0	0
Tripura	–	-23.8	-14.1	-4.6	1.8	3.9	–	-22.7	3.6	-21.7	-22.2	0.7
Overall average	-7.8	-11.5	-8.1	-5.9	-6.2	-7.8	-18.8	-18.0	-11.3	-13.9	-12.4	-13.0

[a] data from the Central Electricity Authority

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 78. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.62 Per capita consumption of electricity: 1986/87 to 1998/99

State/ Union Territory	*1986/87*	*1987/88*	*1988/89*	*1989/90*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*
Northern region	192	202	217	241	249	265	282	286	302	308	306	313	324
Chandigarh	478	483	532	584	708	755	715	626	676	717	795	808	844
Delhi	560	567	576	631	704	758	823	733	747	608	577	613	689
Haryana	272	306	328	365	400	455	507	491	467	503	504	488	503
Himachal Pradesh	145	162	167	180	209	210	208	219	254	288	306	323	334
Jammu and Kashmir	140	163	172	178	193	189	188	195	196	201	218	270	292
Punjab	481	515	660	639	606	616	684	703	759	760	792	798	861
Rajasthan	155	162	182	201	201	231	246	256	270	297	301	314	329
Uttar Pradesh	131	135	143	159	166	174	179	186	204	207	197	200	196
Western region	275	297	314	334	367	391	406	437	468	513	522	538	557
Dadra and Nagar Haveli	228	420	876	879	905	980	1175	1392	1574	1811	2379	3227	3566
Daman and Diu	–	–	–	–	–	–	1015	1182	1548	2016	2335	2721	3599
Goa	339	357	382	396	452	495	541	588	602	707	724	739	740
Gujarat	320	373	397	399	469	504	538	587	608	671	694	705	724
Madhya Pradesh	182	187	188	205	247	267	281	311	335	367	367	377	398
Maharashtra	327	347	372	405	411	434	439	459	500	545	556	577	594
Southern region	202	205	229	249	272	288	312	335	369	377	366	400	406
Andhra Pradesh	205	197	218	227	245	191	312	345	374	368	346	391	404
Karnataka	197	207	233	273	296	296	303	328	364	363	340	387	349
Kerala	135	130	148	164	188	196	200	215	237	249	241	262	305
Lakshadweep	118	137	155	171	154	172	183	207	185	209	234	218	231
Pondicherry	345	439	527	618	720	782	856	843	969	958	867	932	1010
Tamil Nadu	238	249	277	295	323	335	369	386	430	459	468	484	498
Eastern region	119	125	135	129	150	156	162	174	182	195	188	192	201
Andaman and Nicobar Islands	89	112	121	105	117	118	162	168	178	202	210	207	218
Bihar	95	104	110	102	110	108	117	126	134	138	138	142	152
Orissa	146	165	201	181	271	295	297	313	333	370	309	308	313
Sikkim	57	65	68	96	119	20	114	123	143	173	172	178	185
West Bengal	137	135	137	139	148	151	158	171	175	186	194	202	211
North-eastern region	50	62	63	76	89	88	93	92	96	99	104	103	117
Arunachal Pradesh	34	47	55	58	68	58	54	67	66	78	81	101	87
Assam	51	64	63	78	94	90	97	95	98	98	104	100	123
Manipur	48	60	57	80	97	107	104	111	107	118	128	139	75
Meghalaya	83	88	98	108	115	125	129	110	140	143	135	143	150
Mizoram	26	41	49	57	69	69	91	101	112	123	128	95	114
Nagaland	56	62	67	70	75	78	73	68	59	79	88	86	110
Tripura	29	35	41	51	47	53	59	60	66	73	80	90	87
All-India	191	201	217	236	253	268	283	299	320	336	334	348	360

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 77. New Delhi: Power and Energy Division, Planning Commission, Government of India

Table 1.63 Distribution of power sector outlay for 1999/2000 and total outlay: 1999/2000 to 2000/01

State electricity board / Electricity department	*Generation* (%) *(1999/2000)*	*Renovation and modernization* (%) *(1999/ 2000)*	*Transmission and distribution* (%) *(1999/ 2000)*	*Miscellaneous* (%) *(1999/2000)*	*Rural electrification* (%) *(1999/ 2000)*	*Total outlay* (million rupees) *(1999/2000)*	*Total outlay* (million rupees) *(2000/01)*
State electricity board							
Andhra Pradesh	31.65	14.18	46.00	0.45	7.72	8 679.1	26 707.5
Assam	21.76	39.51	34.03	1.85	2.85	1 755.4	928.4
Bihar	4.72	47.17	15.09	0	33.02	1 060.0	1 023.8
Delhi	34.19	2.05	63.45	0.09	0.22	4 750.0	8 125.5
Gujarat	21.42	10.13	62.20	0.83	5.42	8 060.0	8 300.0
Haryana	13.76	5.92	76.32	0	4.00	5 000.0	4 840.0
Himachal Pradesh	71.14	0.41	15.63	2.08	10.75	2 456.9	1 403.7
Jammu and Kashmir	64.15	0.57	26.53	2.04	6.71	3 090.5	3 075.7
Karnataka	60.87	4.48	26.19	2.01	6.45	9 889.9	7 540.0
Kerala	36.13	1.57	45.09	0.35	16.85	6 350.0	6 025.0
Madhya Pradesh	44.59	6.33	39.61	0.21	9.26	8 906.9	6 267.1
Maharashtra	45.60	9.38	36.22	1.79	7.02	16 841.3	17 673.5
Meghalaya	28.79	25.94	9.86	0.52	34.90	771.1	182.0
Orissa	21.33	2.85	63.79	5.10	6.92	10 344.7	7 426.5
Punjab	36.29	3.06	50.65	5.17	4.84	6 200.0	6 223.7
Rajasthan	48.96	0.28	38.20	0.21	12.30	8 419.4	9 936.6
Tamil Nadu	36.74	7.87	51.21	0.82	5.00	10 339.8	10 342.1
Uttar Pradesh	25.87	8.17	50.01	0.18	3.37	19 416.7	14 745.0
West Bengal	70.48	4.48	17.05	1.27	15.77	20 096.0	8 793.3
Electricity department							
Arunachal Pradesh	14.65	0	41.66	6.19	37.49	720.1	818.3
Goa	0.33	0	96.93	2.08	0.66	303.3	300.0
Manipur	2.07	0	55.98	0.89	41.07	300.0	336.0
Mizoram	25.05	2.06	52.48	8.71	11.69	483.2	453.2
Nagaland	26.14	56.82	0	1.59	15.45	88.0	155.7
Pondicherry	8.86	0	84.24	6.91	0	213.3	213.3
Sikkim	28.46	23.28	36.84	7.86	3.56	421.0	317.6
Tripura	16.76	0	67.02	3.35	12.87	298.4	158.1
All-India average	47.58	4.58	33.18	8.90	5.83	268 250.0	265 543.6

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** pp. 18, 24. New Delhi: Power and Energy Division, Planning Commission, Government of India.

For more details, please see TEDDY ONLINE+ [Section: Power (plan statistics)]

Table 1.64 Installed capacity (MW): 31 March 2001

State/ Union Territory / Central sector	*Hydro*	%	*Thermal*	%	*Wind*	%	*Nuclear*	%	*Total*
Northern region									
Chandigarh	0	0	2.00	100.00	0	0	0	0	2.00
Delhi	0	0	617.00	100.00	0	0	0	0	617.00
Haryana	883.90	44.41	1 106.42	55.59	0	0	0	0	1 990.32
Himachal Pradesh	323.67	99.96	0.13	0.04	0	0	0	0	323.80
Jammu and Kashmir	232.69	55.85	183.94	44.15	0	0	0	0	416.63
Punjab	2 398.94	52.97	2 130.00	47.03	0	0	0	0	4 528.94
Rajasthan	971.62	39.03	1 513.50	60.80	4.25	0.17	0	0	2 489.37
Uttar Pradesh	1 510.75	26.92	4 102.00	73.08	0	0	0	0	5 612.75
Central sector	2 010.00	17.51	8 152.00	71.00	0	0	1 320.00	11.50	11 482.00
Private	0	0	0	0	0	0	0	0	0
Sub-total	8 331.57	30.34	17 806.99	64.84	4.25	0.02	1 320.00	4.81	27 462.81
Western region									
Dadra and Nagar Haveli	0	0	0	0	0	0	0	0	0
Goa	0.05	31.25	0	0	0.11	68.75	0	0	0.16
Daman and Diu	0	0	0	0	0	0	0	0	0
Gujarat	547.00	11.93	4 019.28	87.69	17.35	0.38	0	0	4 583.63
Madhya Pradesh	912.91	20.98	3 437.50	79.00	0.59	0.01	0	0	4 351.00
Maharashtra	2 400.17	24.63	7 337.00	75.30	6.44	0.07	0	0	9 743.61
Central sector	0	0	5 752.00	88.33	0	0	760.00	11.67	6 512.00
Private	447 00	7.61	5 108.20	86.91	322.11	5.48	0	0	5 877.31
Sub-total	4 307.13	13.86	25 653.98	82.57	346.59	1.12	760.00	2.45	31 067.70
Southern region									
Andhra Pradesh	2 821.94	48.02	3 051.50	51.93	3.05	0.05	0	0	5 876.49
Karnataka	2 727.55	66.23	1 387.92	33.70	2.57	0.06	0	0	4 118.04
Kerala	1 795.00	88.35	234.60	11.55	2.02	0.10	0	0	2 031.62
Tamil Nadu	1 995.15	38.21	3 207.00	61.41	19.83	0.38	0	0	5 221.98
Lakshadweep	0	0	0	0	0	0	0	0	0
Pondicherry	0	0	32.50	100.00	0	0	0	0	32.50
Central sector	0	0	4 420.00	85.00	0	0	780.00	15.00	5 200.00
Private	30.00	1.11	1 783.26	65.97	890.06	32.92	0	0	2 703.32
Sub-total	9 369.64	37.20	14 116.78	56.05	917.53	3.64	780.00	3.10	25 183.95
Eastern region									
Andaman and Nicobar Islands	0	0	5.00	100.00	0	0	0	0	5.00
Bihar	174.90	8.80	1 813.50	91.20	0	0	0	0	1 988.40
Orissa	1 877.00	81.68	420.00	18.28	1.10	0.05	0	0	2 298.10
Sikkim	32.90	86.81	5.00	13.19	0	0	0	0	37.90
West Bengal	164.71	4.60	3 417.06	95.40	0	0	0	0	3 581.77
Central sector	204.00	2.98	6 637.50	97.02	0	0	0	0	6 841.50
Private	0	0	1 321.52	100.00	0	0	0	0	1 321.52
Sub-total	2 453.51	15.27	13 614.58	84.72	1.10	0.01	0	0	16 069.19

Continued

Table 1.64 Continued

State/ Union Territory / Central sector	*Hydro*	%	*Thermal*	%	*Wind*	%	*Nuclear*	%	*Total*
North-eastern region									
Arunachal Pradesh	29.55	65.05	15.88	34.95	0	0	0	0	45.43
Assam	2.00	0.33	595.19	99.67	0	0	0	0	597.19
Manipur	3.20	25.38	9.41	74.62	0	0	0	0	12.61
Meghalaya	186.71	98.91	2.05	1.09	0	0	0	0	188.76
Nagaland	4.20	66.04	2.00	31.45	0.16	2.52	0	0	6.36
Tripura	16.01	18.76	69.35	81.24	0	0	0	0	85.36
Mizoram	8.26	22.20	28.94	77.80	0	0	0	0	37.20
Central sector	430.00	53.42	375.00	46.58	0	0	0	0	805.00
Private	0	0	24.50	100.00	0	0	0	0	24.50
Sub-total	679.93	37.72	1 122.32	62.27	0.16	0.01	0	0	1 802.41
Total islands	0	0	44.02	100.00	0	0	0	0	44.02
All-India	25 141.78	24.74	72 358.67	71.20	1 269.63	1.25	2 860.00	2.81	101 630.08

Source
Data obtained from the Central Electricity Authority, New Delhi.

For more details, please see TEDDY ONLINE+ [Section: Power (generation utility)]

Table 1.65 Installed capacity of utilities by region and state (MW): 31 March 2001

State/ Union Territory / Central sector	*Hydro*	*Steam*	*Gas*	*Diesel*	*Nuclear*	*Wind*	*Total*
Northern region							
Chandigarh	0	0	0	2.00	0	0	2.00
Delhi	0	335.00	282.0	0	0	0	617.00
Haryana	883.90	1 102.50	0	3.92	0	0	1 990.32
Himachal Pradesh	323.67	0	0	0.13	0	0	323.80
Jammu and Kashmir	232.69	0	175.0	8.94	0	0	416.63
Punjab	2 398.94	2 130.00	0	0	0	0	4 528.94
Rajasthan	971.62	1 475.00	38.5	0	0	4.25	2 489.37
Uttar Pradesh	1 510.75	4 102.00	0	0	0	0	5 612.75
Central sector	2 010.00	5 840.00	2312	0	1320	0	11 482.00
Sub-total	8 331.57	14 984.50	2 807.5	14.99	1320	4.25	27 462.81
Western region							
Dadra and Nagar Haveli	0	0	0	0	0	0	0
Goa	0.05	0		0	0	0.11	0.16
Daman and Diu	0	0	0	0	0	0	0
Gujarat	547.00	3 759.00	243.0	17.28	0	17.35	4 583.63
Madhya Pradesh	912.91	3 437.50	0	0	0	0.59	4 351.00
Maharashtra	2 400.17	6 425.00	912.0	0	0	6.44	9 743.61
Central sector	0	4 460.00	1 292.0	0	760	0	6 512.00
Sub-total	4 307.13	20 791.50	4 845.0	17.48	760	346.59	31 067.70
Southern region							
Andhra Pradesh	2 821.94	2 952.50	99.0	0	0	3.05	5 876.49
Karnataka	2 727.55	1 260.00	0	127.92	0	2.57	4 118.04
Kerala	1 795.00	0	0	234.60	0	2.02	2 031.62
Tamil Nadu	1 995.15	2 970.00	237.0	0	0	19.83	5 221.98
Lakshadweep	0	0	0	0	0	0	0
Pondicherry	0	0	32.5	0	0	0	32.50
Central sector	0	4 070.00	350.0	0	780	0	5 200.00
Sub-total	9 369.64	11 512.50	1 910.9	693.38	780	917.53	25 183.95
Eastern region							
Andaman and Nicobar Islands	0	0	0	5.00	0	0	5.00
Bihar	174.90	1 813.50	0	0	0	0	1 988.40
Orissa	1 877 00	420.00	0	0	0	1.10	2 298.10
Sikkim	32.90	0	0	5.00	0	0	37.90
West Bengal	164.71	3 305.00	100.0	12.06	0	0	3 581.77
Central sector	204.00	6 547.50	90.0	0	0	0	6 841.50
Sub-total	2 453.51	13 407.38	190.0	17.20	0	1.10	16 069.19
North-eastern region							
Arunachal Pradesh	29.55	0	0	15.88	0	0	45.43
Assam	2.00	330.00	244.5	20.69	0	0	597.19
Manipur	3.20	0	0	9.41	0	0	12.61
Meghalaya	186.71	0	0	2.05	0	0	188.76
Nagaland	4.20	0	0	2.00	0	0.16	6.36
Tripura	16.01	0	64.5	4.85	0	0	85.36
Mizoram	8.26	0	0	28.94	0	0	37.20
Central sector	430.00	0	375.0	0	0	0	805.00
Sub-total	679.93	330.00	708.5	83.82	0	0.16	1 802.41
Total islands	0	0	0	44.02	0	0	44.02
All-India	25 141.78	61 025.88	10 461.9	870.89	2860	1 269.63	101 630.08

Source
Data obtained from the Central Electricity Authority, New Delhi.

For more details, please see TEDDY ONLINE+ [Section: Power (generation utility)]

Table 1.66 Annual plant load factor (%) of thermal stations: 1991/92 to 2000/01

State electricity board / Sector	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*
State electricity board										
Northern region	58.0	62.0	64.0	59.1	62.0	64.7	66.7	67.2	70.9	73.1
Haryana	45.8	49.9	40.5	44.7	42.9	47.7	49.4	48.8	53.0	49.9
Punjab	52.8	58.3	63.5	56.7	55.0	65.7	69.1	69.4	74.7	77.9
Rajasthan	65.7	77.0	81.0	75.6	73.7	75.6	80.5	78.1	82.3	85.2
Uttar Pradesh	44.3	50.5	50.3	43.9	47.3	49.1	48.8	48.9	49.8	56.7
Western region	59.6	59.7	63.4	63.8	68.1	70.2	70.3	70.5	72.3	73.4
Gujarat	56.9	61.6	60.4	60.5	65.3	64.8	65.6	63.6	63.4	66.9
Maharashtra	61.3	59.7	64.1	61.2	64.9	68.7	68.3	68.4	71.7	72.7
Madhya Pradesh	49.2	52.5	56.1	58.2	58.7	62.3	66.0	67.8	69.4	66.3
Southern region	60.8	62.6	68.3	69.1	74.7	75.8	77.1	75.4	79.6	81.9
Andhra Pradesh	62.1	65.0	68.7	70.2	77.4	78.3	82.0	76.9	83.2	85.2
Karnataka	59.1	49.4	66.9	64.9	67.7	70.2	75.2	81.7	82.3	81.3
Tamil Nadu	55.7	65.2	69.0	68.1	76.1	72.3	68.1	65.9	72.3	74.9
Eastern region	37.3	39.8	44.8	43.7	42.7	42.2	43.0	44.3	46.1	48.0
Bihar	21.3	25.2	24.4	20.0	17.4	15.3	16.1	22.5	19.7	19.0
Orissa	30.2	34.5	35.5	29.0	67.0	69.4	65.3	76.2	85.6	81.9
West Bengal	30.8	31.1	40.5	41.2	34.6	39.2	40.0	36.8	39.8	36.2
North-eastern region	24.6	24.3	19.9	26.8	28.6	27.1	21.3	18.7	18.2	18.6
Assam	24.6	24.3	19.9	26.7	28.6	27.1	21.3	18.7	18.2	18.6
Total	50.6	54.1	56.6	55.0	58.0	60.3	60.9	60.8	63.7	65.6
Central sector	64.5	62.7	69.8	69.2	70.9	71.0	70.4	71.1	73.8	74.3
National Thermal Power Corporation	69.2	68.8	76.9	76.2	76.7	76.4	74.4	75.6	79.7	79.5
Neyveli Lignite Corporation	66.3	56.4	55.5	60.4	67.6	70.3	72.5	73.6	73.2	80.1
Damodar Valley Corporation	33.6	32.3	42.3	38.2	37.8	35.6	38.4	38.1	35.9	36.2
Durgapur Power Ltd	17.8	28.7	26.3	26.6	26.5	29.5	25.3	17.6	24.8	17.3
Delhi Vidyut Board	57.2	54.0	49.0	53.9	51.7	41.7	47.2	38.2	49.9	49.5
West Bengal Power Development Corporation	61.4	58.1	68.2	60.4	57.6	56.5	52.8	60.7	56.2	55.9
Private sector	64.5	54.1	56.6	65.9	72.3	71.2	71.1	68.3	68.9	73.0
Ahmedabad Electric Company Ltd	67.3	62.5	67.0	69.1	69.3	71.4	71.3	74.4	81.7	82.5
Trombay	53.0	54.3	48.8	60.6	72.8	68.8	63.5	61.0	60.8	70.3
Calcutta Electricity Supply Company	58.3	67.5	71.3	75.6	78.9	74.9	76.9	72.4	64.0	66.2
All-India	55.3	57.1	61.0	60.0	63.0	64.4	64.7	64.6	67.3	69.0

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments, 1997.** p 51.
New Delhi: Power and Energy Division, Planning Commission, Government of India

For more details, please see TEDDY ONLINE+ [Section: Power (generation thermal)]

Table 1.67 Annual gross generation in utilities (GWh): 1975/76 to 2000/01

Type	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*
Hydel	33 301	46 542	51 021	71 641	72 757	69 869	70 463	82 712	72 579	68 901	74 582	82 690	80 533	74 346
Thermal (includes diesel, wind, gas, and steam)	43 303	61 301	114 347	186 546	208 747	224 766	248 189	262 130	299 316	317 811	337 083	353 655	386 776	408 208
Nuclear	2 626	3 001	4 982	6 141	5 524	6 726	5 398	5 648	7 982	9 071	10 083	12 015	13 267	16 896
Total	79 230	110 844	170 350	264 328	287 028	301 361	324 050	350 490	379 877	395 783	421 748	448 360	480 576	499 450

Sources

1 Planning Commission. 1996. ***Annual Plan 1995/96***. p. 337. New Delhi: Planning Commission, Government of India. 597 pp.

2 CEA. 1999. **Public Electricity Supply, All India Statistics, General Review, 1995/96**. pp. 59, 68. New Delhi: Central Electricity Authority. 214 pp.

3 MoP. 1998. ***Annual Report 1997/98***. New Delhi: Ministry of Power.

4 Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments, 1997**. pp. 53–56. New Delhi: Power and Energy Division, Planning Commission, Government of India.

For more details, please see TEDDY ONLINE+ [Section: Power (generation utility)]

Table 1.68 Captive capacity (MW) and generation (GWh): 1990/91 to 1997/98 (in respect of installed capacity of 1 MW and above)

Year and item	*Steam*	*Diesel*	*Others*	*Total*
1990/91				
Installed capacity	4991.1	3031.7	478.8	8501.6
Energy generated	20005.7	3216.3	1859.8	25081.8
PLF (Plant load factor) (%)	45.8	12.1	44.3	34.1
1991/92				
Installed capacity	5377.1	3291.1	500.0	9168.2
Energy generated	23409.4	3247.8	1922.8	28580 0
PLF (%)	49.7	11.3	43.9	35.0
1992/93				
Installed capacity	5540.7	3726.7	637.1	9904.5
Energy generated	24679.8	3851.0	3797.0	32327.8
PLF (%)	54.2	11.8	68.0	37.3
1993/94				
Installed capacity	5793.0	3995.1	786.6	10574.7
Energy generated	25407.5	3684.4	3170.7	32262.6
PLF (%)	50.1	10.5	46.0	34.8
1994/95				
Installed capacity	6010.5	4156.1	846.4	11013.0
Energy generated	27387.9	4102.7	3553.3	35043.9
PLF (%)	52.0	11.3	47.9	36.3
1995/96				
Installed capacity	6305.3	4199.4	1124.3	11629.0
Energy generated	28751.7	4334.4	5056.1	38142.2
PLF (%)	–	–	–	–
1996/97				
Installed capacity	6151.7	4529.9	1234.7	11916.3
Energy generated	29127.9	6573.4	5113.7	40815.0
PLF (%)	–	–	–	–
1997/98				
Installed capacity	6628.9	4958.1	1416.8	13003.9
Energy generated	30683.7	7463.6	5903.3	44050.6
PLF (%)	–	–	–	–

Source

CEA. 2000. **Public Electricity Supply, All India Statistics, General Review, 1997/98.** New Delhi: Central Electricity Authority. 221 pp.

For more details, please see TEDDY ONLINE+ [Section: Power (generation captive)]

Table 1.69 Purchase of power by major sources (**million kWh**): 1997/98 to 2000/01

State electricity board / Electricity department	*1997/98*		*1998/99*		*1999/2000*		*2000/01*	
	Central sector	*Others*	*Central sector*	*Others*	*Central sector*	*Others*	*Central sector*	*Others*
State electricity board								
Andhra Pradesh	8 632	2 555	7 844	9 380	9 187	31 570	10 411	33 841
Assam	1 035	712	1 326	652	1 790	280	1 790	280
Bihar	6 594	1 388	7 274	1 621	8 754	1 113	8 813	1 600
Delhi (DVB)	11 662	48	14 262	0	14 771	548	15 780	630
Gujarat	9 738	2 917	8 789	6 376	6 568	10 022	5 897	11 231
Haryana	6 203	441	8 459	406	10 953	186	12 437	251
Himachal Pradesh	1 151	902	945	1 031	1 288	1 120	1 197	1 197
Jammu and Kashmir	3 918	49	4 679	45	4 800	51	5 379	70
Karnataka	5 022	15 464	5 549	16 054	5 555	18 895	4 800	19 839
Kerala	4 201	35	3 301	295	4 292	387	5 890	366
Madhya Pradesh	11 500	1 392	13 310	997	14 158	892	15 835	900
Maharashtra	10 702	4 120	11 440	4 060	11 088	8 199	11 088	9 733
Meghalaya	78	0	95	0	81	0	125	0
Orissa	4 091	6 233	2 927	7 640	3 384	6 846	2 380	8 775
Punjab	6 078	569	5 676	620	5 551	602	5 704	734
Rajasthan	9 965	965	9 965	965	10 740	560	10 900	583
Tamil Nadu	10 005	993	10 675	2 356	10 013	4 308	10 443	4 040
Uttar Pradesh	14 257	283	15 450	359	16 023	77	16 540	100
West Bengal	3 177	5 847	3 689	6 442	3 960	6 540	2 900	8 300
Sub-total	128 010	44 914	135 654	59 599	142 959	92 196	148 308	102 470
Electricity department								
Arunachal Pradesh	79	0	85	0	90	[?]	100	0
Goa	1 379	0	1 502	0	1 231	194	1 276	312
Manipur	342	4	347	29	350	0	350	0
Mizoram	126	14	117	53	130	53	137	67
Nagaland	162	23	180	0	189	0	194	0
Pondicherry	842	246	916	306	1 122	312	1 234	343
Sikkim	53	0	73	0	70	0	45	0
Tripura	144	4	219	0	235	1	250	1
Sub-total	3 127	292	3 440	388	3 416	559	3 586	723
Grand total	131 137	45 205	139 094	59 687	146 375	92 755	151 894	103 193

DVB - Delhi Vidyut Board

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments**. p. 61. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.70 Installed capacity in selected industries: 1997/98

	Installed capacity (kW) as on 31 March 1998							*Energy generated (GWh) (1997/98)*					
Industry	*Number of factories*	*Hydro*	*Steam*	*Diesel*	*Gas*	*Wind*	*Total*	*Hydro*	*Steam*	*Diesel*	*Gas*	*Wind*	*Total*
Aluminium (primary)	4	0	1 669 500	0	0	0	1 669 500	0	10 423.16	0	0	0	10 423.16
Aluminium (secondary)	8	0	62 000	8 824	0	0	70 824	0	287 25	4.77	0	0	292.02
Automobile	32	0	0	138 533	60 000	0	198 533	0	0	88.25	248 00	0	336.25
Cement (primary)	96	0	353 200	928 551	0	0	1 281 751	0	1 293.48	1743.98	0	0	3 037.46
Cement (secondary)	15	0	0	47 275	0	0	47 275	0	0	40 45	0	0	40.45
Chemicals	170	0	508 670	469 455	68 560	24 450	1 071 135	0	1 990 85	875.11	105.41	17 91	2 989 28
Collieries	8	0	95 400	8 280	0	0	103 680	0	226.41	2.70	0	0	229.11
Electrical engineering	68	0	15 000	159 724	6 000	0	180 724	0	15.13	122.59	42.12	0	179.84
Fertilizer	41	0	616 750	93 769	407 560	0	1 118 079	0	2 704.46	318.79	1309.82	0	4 333.07
Food product	56	0	1 600	105 429	2 800	2 025	111 854	0	1.61	59.93	2.51	2.96	67.01
Heavy engineering	42	0	0	176 187	0	13 400	189 587	0	0	115 27	0	16 63	131 90
Iron and steel (primary)	20	0	1 377 000	77 476	24 000	0	1 478 476	0	7 232.74	8.59	0	0	7 241.33
Iron and steel (secondary)	60	0	6 000	165 461	30 000	900	202 361	0	37.37	133.19	233.61	0.69	404.86
Jute	64	0	0	166 537	0	0	166 537	0	0	122.83	0	0	122.83
Light engineering	92	0	1 500	223 696	0	0	225 196	0	1.02	140 05	0	0	141 07
Mineral oil and petroleum	20	0	331 150	42 281	352 822	15 315	741 568	0	1 402.47	141.42	1840 60	0	3 384.49
Mining and quarrying	7	0	8 600	29 571	0	0	38 171	0	6.34	14.29	0	0	20 63
Miscellaneous	109	17 250	35 300	275 049	317 300	0	644 899	50	90.08	279.06	1747.75	0	2 166 89
Non-ferrous	27	0	116 800	266 686	20 000	0	403 486	0	394.28	633 37	27 00	0	1 054 65
Paper	55	0	480 845	114 893	0	0	595 738	0	1 970.18	248.80	0	0	2 218.98
Plastic	1	0	0	0	12 500	0	12 500	0	0	0	37.88	0	37.88
Rubber	28	0	13 100	113 657	0	0	126 757	0	17 90	185.57	0	0	203.47
Sugar	218	0	681 485	117 067	0	0	798 552	0	1 585 81	214 87	0	0	1 800.68
Textile	444	3 500	254 970	1 228 726	28 900	9 650	1 525 746	28.84	1 003.16	1969.74	180.96	10.62	3 193.32
Total	1685	20 750	6 628 870	4 958 127	1 330 442	65 740	13 003 929	78.84	30 683.70	7463 62	5775 66	48 81	44 050 63

Source

CEA. 2000 **Public Electricity Supply, All India Statistics, General Review, 1996/97.** pp. 102–103. New Delhi: Central Electricity Authority

For more details, please see TEDDY ONLINE+ [Section: Power (generation captive)]

Table 1 71 Electricity production and consumption (GWh) in selected industries: 1997/98

Industry	*Energy used in station auxiliaries*	*Net energy generation*	*Energy sold to utilities*	*Energy used in the industry out of self generation*	*Energy purchased from utilities*	*Energy consumed in the industry*
Aluminium (primary)	1081.01	9342.15	1100.32	8241.83	352.41	8594.24
Aluminium (secondary)	83.24	208.78	0	208.78	142.27	351.05
Automobiles	2.98	333.27	92.83	240.44	581.18	821.62
Cement (primary)	222.46	2815.00	0	2815.00	4395.59	7210.59
Cement (secondary)	0.91	39.54	0	39.54	269.37	308.91
Chemical	275.01	2714.27	0	2714.27	3239.08	5953.35
Colliery	24.96	204.15	0	204.15	1095.67	1299.82
Electrical engineering	12.09	167.75	0	167.75	517.44	685.19
Fertilizer	334.64	3998.43	189.97	3808.46	2778.35	6586.81
Food product	1.61	65.40	0	65.40	336.69	402.09
Heavy engineering	3.58	128.32	0	128.32	836.83	965.15
Iron and steel (primary)	1203.19	6038.14	371.63	5666.51	5386.57	11053.08
Iron and steel (secondary)	13.53	391.33	0	391.33	1282.20	1673.53
Jute	3.98	118.85	0	118.85	790.98	909.83
Light engineering	2.77	138.30	0	138.30	720.17	858.47
Mineral oil and petroleum	197.69	3186.80	104.30	3082.50	174.82	3257.32
Mining and quarrying	0.56	20.07	0	20.07	466.46	486.53
Miscellaneous	49.68	2117.21	375.68	1741.53	34.81	1776.34
Non-ferrous	61.58	993.07	174.74	818.33	1711.39	2529.72
Paper	212.93	2006.05	0	2006.05	934 46	2940.51
Plastic	1.89	35.99	0	35.99	0	35.99
Rubber	8.84	194.63	0	194.63	394.58	589.21
Sugar	108.06	1692.62	92.04	1600.58	356.12	1956.70
Textile	159.45	3033.87	40	2993.87	5790.96	8784.83
Total	4066.64	39983.99	2541.51	37442.48	32588.40	70030.88

Source

CEA. 2000. **Public Electricity Supply, All India Statistics, General Review, 1997/98.** pp. 104–105. New Delhi: Central Electricity Authority.

For more details, please see TEDDY ONLINE+ [Section: Power (generation captive)]

Table 1.72 Details of nuclear power projects: 31 March 2001

Project	*District and state*	*Number of units and capacity* (MW)	*Total capacity* (MW)
Under operation			
Tarapur (units 1 and 2)	Thane, Maharashtra	2 × 160	320
Rajasthan (unit 1)	Kota, Rajasthan	1 × 150	150
Rajasthan (unit 2)	Kota, Rajasthan	1 × 200	200
Rajasthan (units 3 and 4)	Kota, Rajasthan	2 × 220	440
Chennai (units 1 and 2)	Chengalpettu, Tamil Nadu	2 × 220	440
Narora (units 1 and 2)	Bulandshahr, Uttar Pradesh	2 × 220	440
Kakrapar	Gujarat	2 × 220	440
Kaiga (units 1 and 2)	Uttar Kannada, Karnataka	2 × 220	440
Total			2870
Under construction			
Tarapur (units 3 and 4)	Thane, Maharashtra	2 × 500	1000
Total			1000
Approved for construction in future projects			
Kaiga (units 3 to 6)	Uttar Kannada, Karnataka	4 × 220	880
Rajasthan (units 5 and 6)	Kota, Rajasthan	2 × 500	1000
Kundankulam (units 1 and 2)	Tirunelveli, Tamil Nadu	2 × 1000	2000
Total			3880
Grand total			7750

Sources

1 CEA. 1995. *Vidyut Bharti* (July-September 1995) p. 51. New Delhi: Central Electricity Authority. 56 pp.

2 *Nu-Power* **14**(1) (2000).

For more details, please see TEDDY ONLINE+ [Section: Power (generation nuclear)]

Table 1.73 Potential and development of hydro-electric power projects (MW) in different regions: 31 March 1996

Region	*Hydro-electric potential at 60% load factor*	*Hydro-electric potential under development (equivalent to 60% load factor)*	*Hydro-electric potential developed (equivalent to 60% load factor)*
North	30 155	2204.6 (7.3)	4 138.2 (13.7)
West	5 679	1536.1 (27.1)	1 818.8 (32.0)
South	10 763	1108.2 (10.3)	5 293.8 (49.2)
East	5 590	720.0 (12.9)	908.8 (16.3)
North-east	31 857	309.9 (1.0)	315.5 (1.0)
All-India	84 044	5878.8 (7.0)	12 475.1 (14.8)

Note

Figures in parentheses indicate percentages.

Sources

1 CEA. 1996. **Review of Performance of Hydro Power Stations, 1995/96.** p. 1. New Delhi: Hydro Electric Development Potential Directorate, Hydro Wing, Central Electricity Authority. 172 pp.

2 Data obtained from the Central Electricity Authority, New Delhi

For more details, please see TEDDY ONLINE+ [Section: Power (generation hydro)]

Table 1.74 Potential hydroelectric power projects (MW) of different basins

River basin	*Hydro-electric potential at 60% load factor*	*Hydro-electric potential under development (equivalent to 60% load factor)*	*Hydro-electric developed potential (equivalent to 60% load factor)*
Indus	19 988	1224.1 (6.1)	2 761 6 (13.8)
Ganga	10 715	1000.2 (9 3)	1 841.6 (17.2)
Central Indian rivers	2 740	1531.3 (55.9)	631 (23.0)
West-flowing rivers	6 149	1006.3 (16.4)	3 191 8 (51.9)
East-flowing rivers	9 532	694.0 (7.3)	3 658.1 (38.4)
Brahmaputra	34 920	422.8 (1.2)	391.0 (1.1)
Total	84 044	5878.7 (7.0)	12 475.1 (14.8)

Note

Figures in parentheses indicate percentages.

Source

CEA. 1996. **Review of Performance of Hydro Power Stations, 1995/96.** p. 2. New Delhi: Hydro Electric Development Potential Directorate, Hydro Wing, Central Electricity Authority. 172 pp.

For more details, please see **TEDDY ONLINE+ [Section: Power (generation hydro)]**

Table 1.75 Transmission and distribution losses as a percentage of availability in state electricity departments: 1991/92 to 2000/01

State	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*[a]	*1999/2000*[b]	*2000/01*[c]
Andhra Pradesh	20.3	19.2	19.1	18.9	18.9	33.1	32.5	31.9	31.4	31.0
Arunachal Pradesh	28.2	34.9	31.6	31.0	36.0	32.6	19.2	21.3	20.5	18.0
Assam	22.7	21.0	20.8	24.9	26.2	26.4	30.1	38.1	37.0	35.0
Bihar	18.3	20.5	19.0	24.0	25.9	25.3	25.4	23.0	23.0	22.0
Delhi	–	–	–	–	48.0	49.6	42.3	49.2	47.0	45.0
Daman and Diu	15.9	0	0	0	0	0	0	0	0	0
Goa	23.8	20.8	21.8	26.2	28.5	23.5	23.4	29.1	24.3	24.0
Gujarat	23.6	21.1	21.3	20.0	18.3	21.4	21.7	20.1	19.6	19.4
Haryana	26.8	25.4	25.5	28.5	31.4	32.8	33.4	33.8	27.0	25.0
Himachal Pradesh	19.2	18.5	17.3	17.4	17.5	18.4	19.2	18.2	17.6	17.3
Jammu and Kashmir	50.1	45.3	47.7	46.9	48.6	50.0	47.5	47.1	47.0	46.5
Karnataka	19.3	18.7	18.6	18.9	18.5	18.9	18.6	29.9	30.0	30.0
Kerala	22.5	21.0	20.2	20.1	20.1	21.4	17.9	21.4	21.1	20.8
Lakshadweep	17.4	0	0	0	0	0	0	0	0	0
Madhya Pradesh	25.8	22.2	20.2	20.1	19.5	20.6	19.7	19.5	20.7	20.5
Maharashtra	18.6	16.4	15.8	15.3	15.4	17.7	17.1	17.2	17.0	16.7
Manipur	24.4	22.5	22.5	22.0	21.5	23.0	21.5	59.1	40.0	30.0
Meghalaya	11.7	12.2	10.7	18.7	17.8	19.5	17.9	20.1	20.4	20.3
Mizoram	34.9	28.1	28.0	28.0	27.0	34.4	47.0	45.1	42.5	40.0
Nagaland	23.1	32.4	31.6	30.8	30.0	30.5	29.5	29.0	28.5	29.2
Orissa	25.3	23.5	23.4	23.8	46.9	50.4	49.2	48.5	6.0	6.0
Punjab	21.8	18.7	18.5	18.3	18.2	18.9	17.8	16.8	16.8	16.9
Rajasthan	23.1	24.5	25.2	25.0	28.5	25.9	26.5	26.5	29.5	22.0
Sikkim	25.9	21.8	21.5	21.2	21.0	29.2	20.1	20.1	20.0	20.0
Tamil Nadu	18.4	17.5	17.3	16.9	17.0	17.0	16.8	16.9	16.7	16.5
Tripura	32.0	30.5	30.0	30.0	30.0	28.8	29.3	28.5	28.0	28.0
Uttar Pradesh	26.1	24.1	23.2	22.6	22.8	28.0	25.5	26.3	25.5	25.0
West Bengal	19.7	23.7	22.4	21.1	20.7	20.1	20.0	25.5	28.0	28.0
All-India (utilities)	22.8	19.8	20.2	20.3	22.2	24.5	24.8	–	–	–

[a] provisional
[b] revised
[c] estimate

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 66. New Delhi: Power and Energy Division, Planning Commission, Government of India.

For more details, please see TEDDY ONLINE+ [Section: Power (transmission)]

Table 1.76 Length of transmission and distribution lines (**circuit km**) by region and state: 31 March 1998

Region / State[a]	*Total*	*400 kV*	*230 kV*	*220 kV*	*132 kV*	*110/90 kV*	*78/66 kV*	*33 kV*	*22/20 kV*	*15/11 kV*	*6.6 kV*	*3.3/2.2 kV*	*Distribution lines up to 500 V*
North													
Chandigarh	1 828	0	0	0	0	0	64	28	0	662	0	28	1 046
Delhi	33 678	72	0	478	0	0	508	1 016	0	8 976	0	0	22 628
Haryana	165 656	0	0	840	1 828	0	1 484	3 386	0	54 240	0	0	103 878
Himachal Pradesh[b]	64 922	0	0	192	753	0	330	2 150	4 484	13 085	0	45	43 883
Jammu and Kashmir[b]	41 884	0	0	224	659	0	0	1 693	0	11 538	0	0	27 770
Punjab	246 969	574	0	5 756	2 948	0	3 973	1 573	0	82 824	122	0	149 199
Rajasthan	370 752	287	0	6 204	9 602	0	303	23 180	0	138 928	56	14	192 178
Uttar Pradesh	469 725	2 139	0	6 038	10 271	0	3 139	25 325	0	192 481	0	0	230 332
Central sector	10 228	5 525	0	3 073	0	0	0	0	0	0	0	0	0
Sub-total	1 405 642	8 597	0	22 805	26 061	0	9 801	58 351	4 484	502 734	178	87	770 914
West													
Dadra and Nagar Haveli	1 314	0	0	0	0	0	59	0	0	355	0	0	900
Daman and Diu	798	0	0	0	0	0	49	0	0	185	0	0	560
Goa	9 174	0	0	24	0	198	0	828	0	2 304	0	0	5 820
Gujarat	315 116	1 861	0	8 086	4 273	0	11 263	150	5 441	112 082	0	107	171 853
Madhya Pradesh	602 485	3 076	2	7 828	11 627	0	362	33 932	0	191 737	0	49	353 874
Maharashtra	631 972	5 196	0	9 555	8 053	3 190	3 264	22 404	20 690	149 519	179	0	409 920
Central sector	6 266	5 356	0	910	0	0	0	0	0	0	0	0	0
Sub-total	1 567 125	15 489	2	26 403	23 953	3 388	14 997	57 314	26 131	456 186	179	156	912 927
South													
Andhra Pradesh	589 554	0	0	8 063	11 306	0	633	26 549	0	158 617	0	34	384 315
Karnataka	596 141	910	0	6 901	0	5 629	5 450	6 016	0	120 015	0	0	451 220
Kerala	173 433	0	0	1 742	0	2 659	2 673	0	0	27 262	0	0	139 097
Lakshadweep	251	0	0	0	0	0	0	0	0	0	0	26	188
Pondicherry	4 988	0	63	0	0	188	0	0	664	252	0	0	3 788
Tamil Nadu	541 059	0	5689	0	0	10 378	2 866	4 541	31 369	72 649	0	0	412 355
Central sector	6 510	6 446	0	64	0	0	0	0	0	0	0	0	0
Sub-total	1 911 936	7 356	5752	16 770	11 306	18 854	11 622	37 106	32 033	380 077	0	60	1 390 963

East													
Andaman and Nicobar Islands	3 775	0	0	0	0	0	0	283	0	721	0	0	2 771
Bihar	178 824	235	0	1 717	4 435	0	0	8 965	0	74 041	0	0	89 431
Damodar Valley Corporation	5 382	0	0	1 152	3 146	0	0	1 084	0	0	0	0	0
Orissa	126 585	242	0	3 594	4 277	0	136	9 440	0	50 141	0	0	58 755
Sikkim[b]	5 156	0	0	0	0	0	273	0	0	2 133	0	15	2 735
West Bengal	163 939	903	0	1 562	3 885	0	826	7 988	50	37 641	2623	34	78 427
Central sector	5 602	3 675	0	1 927	0	0	0	0	0	0	0	0	0
Sub-total	489 263	5 055	0	9 952	15 743	0	1 235	27 760	50	194 677	2623	49	232 119
North-East													
Arunachal Pradesh	10 521	0	0	0	0	0	0	2 832	0	2 953	0	0	4 736
Assam	83 896	0	0	1 365	2 041	0	730	5 014	0	32 640	0	0	42 106
Manipur	11 789	0	0	0	389	0	0	514	0	4 853	0	0	6 033
Meghalaya	13 306	0	0	0	595	0	0	1 135	0	6 490	0	0	5 086
Mizoram[b]	7 092	0	0	0	323	0	110	687	0	3 507	0	0	2 465
Nagaland	10 675	0	0	0	240	0	236	1 874	0	4 007	0	0	4 318
Tripura[b]	10 139	0	0	0	228	0	297	512	0	4 981	0	0	4 121
Central sector	1 127	0	0	341	781	0	0	0	0	0	0	0	0
Sub-total	148 540	0	0	1 706	4 597	0	1 373	12 568	0	59 431	0	0	68 865
All-India total	5 522 506	36 497	5754	77 636	81 660	22 242	39 028	193 099	62 698	1 593 105	2980	352	3 405 788

[a] includes Union Territory also

[b] data repeated

Source

CEA. 2000. **Public Electricity Supply, All India Statistics, General Review,** 1997/98. pp. 160–163. New Delhi: Central Electricity Authority.

For more details, please see TEDDY ONLINE+ [Section: Power (transmission)]

Table 1.77 Villages electrified and rural population benefitted by electricity in different regions and states: 1997 to 2000

Region / State[a]	*Total number of villages (31 March 1997)*	*Total electrified (31 March 1997)*	*Electrified (%) (31 March 1997)*	*Population covered (1991 census) (%) (31 March 1997)*	*Number of villages electrified in March 1999 (cumulative)*	*Number of villages electrified in March 2000 (cumulative)*
North						
Chandigarh	25	25	100.0	100.0	0	0
Delhi	199	199	100.0	100.0	0	0
Haryana	6 759	6 759	100.0	100.0	6 759	6 759
Himachal Pradesh	16 997	16 635	97.9	97.4	16 635	16 844
Jammu and Kashmir	6 477	6 301	–	90.0	6 315	6 315
Punjab	12 428	12 428	100.0	100.0	12 428	12 428
Rajasthan	37 889	33 554	88.6	95.9	34 940	35 447
Uttar Pradesh	112 803	87 079	77.2	80.0	88 641	89 117
Sub-total	193 577	162 980	84.2	86.7	165 718	166 910
West						
Daman and Diu	24	24	100.0	100.0	0	0
Dadra and Nagar Haveli	71	71	100.0	100.0	0	0
Goa	360	360	–	100.0	360	360
Gujarat	18 028	17 927	99.4	99.8	17 940	17 940
Madhya Pradesh	71 526	67 496	94.4	98.1	68 259	68 346
Maharashtra	40 412	40 412	–	100.0	40 412	40 412
Sub-total	130 421	126 290	96.8	99.2	126 611	126 698
South						
Andhra Pradesh	26 586	26 565	–	100.0	26 565	26 565
Karnataka	27 066	26 663	98.5	99.9	26 676	26 691
Kerala	1 384	1 384	100.0	99.7	1 384	1 384
Lakshadweep	7	7	100.0	100.0	0	0
Pondicherry	263	263	100.0	100.0	0	0
Tamil Nadu	15 822	15 822	100.0	99.5	15 822	15 822
Sub-total	71 128	70 704	99.4	99.8	70 447	70 462
East						
Andaman and Nicobar Islands	504	501	–	100.0	0	0
Bihar	67 513	47 832	–	67.2	47 845	47 888
Orissa	46 989	32 825	69.9	70.7	34 442	35 190
Sikkim	447	405	–	81.3	405	405
West Bengal	37 910	29 271	–	74.3	29 402	29 515
Sub-total	153 363	110 834	72.3	70.2	112 094	112 998
North-East						
Arunachal Pradesh	3 649	2 061	56.5	66.3	2 215	2 171
Assam	24 685	18 999	77.0	76.9	19 046	19 019
Manipur	2 182	1 888	86.5	82.6	1 990	2 001
Meghalaya	5 484	2 467	–	70.0	2 494	2 510
Mizoram	698	672	96.3	99.5	684	691
Nagaland	1 216	1 153	94.8	98.0	1 153	1 196
Tripura	855	788	92.2	71.9	806	810
Sub-total	38 769	28 028	72.3	77.2	26 173	26 227
All-India	587 258	498 836	84.9	87.7	504 711	506 916

[a] includes Union Territory also

Sources

1 Planning Commission. 2000. **Annual Report on the Working of State Electricity Boards and Electricity Departments**. p. 82. New Delhi: Power and Energy Division, Planning Commission, Government of India.

2 CEA. 1999. **Public Electricity Supply, All India Statistics, General Review, 1996/97**. pp. 159–162. New Delhi: Central Electricity Authority. 214 pp.

3 http://www.cea.nic.in/data/opt_village.htm

For more details, please see TEDDY ONLINE+ [Section: Power (rural)]

Table 1.78 Energization of pump-sets: March 1995 to March 2000

	Energization of pump-sets					
State / Union Territory	*March 1995 (cumulative)*	*March 1996 (cumulative)*	*March 1997 (cumulative)*	*March 1998 (cumulative)*	*March 1999 (cumulative)*	*March 2000 (cumulative)*
State						
Andhra Pradesh	1 605 807	1 642 993	1 821 291	1 824 689	1 884 571	1 918 712
Assam	0	3 675	3 675	3 675	3 675	3 675
Bihar	264 755	267 371	269 345	270 277	271 090	272 629
Goa	5 441	5 732	6 063	6 454	6 590	6 658
Gujarat	551 551	568 858	591 564	617 495	643 757	670 422
Haryana	404 107	406 612	408 461	409 404	410 224	411 022
Himachal Pradesh	4 141	4 441	4 780	5 098	5 392	5 762
Jammu and Kashmir	3 586	4 716	5 088	5 621	5 621	5 621
Karnataka	973 288	1 014 918	1 049 465	1 082 150	1 141 824	1 181 963
Kerala	289 866	304 904	314 632	329 355	353 405	373 862
Madhya Pradesh	1 087 404	1 131 435	1 176 317	1 229 016	1 274 873	1 298 108
Maharashtra	1 883 152	2 025 973	2 091 718	2 151 191	2 208 738	2 275 531
Manipur	45	45	45	45	45	45
Meghalaya	65	65	65	65	65	65
Mizoram	0	0	0	0	0	0
Nagaland	176	176	176	176	176	176
Orissa	65 145	69 184	70 144	72 047	73 359	74 526
Punjab	681 432	709 916	726 221	735 162	744 972	755 141
Rajasthan	488 770	514 758	539 762	565 068	590 119	613 061
Sikkim	0	0	0	0	0	0
Tamil Nadu	1 487 654	1 528 807	1 567 322	1 609 242	1 643 915	1 680 312
Tripura	1 738	1 764	1 764	1 764	1 764	2 094
Uttar Pradesh	727 937	761 272	778 512	790 157	806 270	817 673
West Bengal	98 329	101 232	102 773	104 383	107 238	109 291
Total	10 585 006	11 068 847	11 529 183	11 812 534	12 177 683	12 476 349
Union Territory						
Total	34 578	35 243	36 159	36 872	37 453	37 895
Grand total	10 619 584	11 104 090	11 565 342	11 849 406	12 215 136	12 514 244

Sources

1 Planning Commission. 2000. **Annual Report on the Working of State Electricity Boards and Electricity Departments**. p. 83
New Delhi: Power and Energy Division, Planning Commission, Government of India.

2 http.//www.cea.nic.in/data/opt_pumset.htm

Table 1.79 Progress in rural electrification: 1970/71 to 1999/2000

Item	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Villages electrified (thousands)	104.9	272.3	390.3	481.1	487.2	490.8	494.2	497.7	495.7	498.6	502.0	504.8	506.9
As percentage of total number of villages	18.5	47.3	67.7	83.1	84.1	84.8	85.3	86.0	86.7	87.2	87.8	–	–
Pumpsets energized (thousands)	1629.4	4330.5	6152.0	8909.1	9391.1	9851.2	10 276.6	10 721.3	11 104.1	11 565.3	11 849.4	12 216.7	12 514.2

Sources

1 CEA. 1996. **Public Electricity Supply, All India Statistics, General Review, 1995/96**. pp. 210-213. New Delhi: Central Electricity Authority. 214 pp.

2 MoP. 1998. ***Annual Report 1997/98***. New Delhi: Ministry of Power.

3 Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments**. p. 80. New Delhi: Power and Energy Division, Planning Commission, Government of India.

For more details, please see TEDDY ONLINE+ [Section: Power (rural)]

Table 1.80 Number of towns electrified for various population groups: 1970/71 to 1995/96

Population	*1970/71*	*1980/81*[a]	*1985/86*[b]	*1990/91*[b]	*1991/92*[c]	*1992/93*[c]	*1993/94*[c]	*1994/95*[c]	*1995/96*[c]
5000 and below	266	296	297	297	356	356	356	356	356
5001 to 9999	844	820	820	820	943	943	943	943	943
10 000 to 19 999	819	987	987	987	1273	1273	1273	1273	1273
20 000 to 49 999	518	652	652	652	892	892	892	892	892
50 000 to 99 999	139	219	219	219	330	330	330	330	330
100 000 and above	107	151	151	151	227	227	227	227	227
Total	2693	3125	3126	3126	4021	4021	4021	4021	4021

[a] number of towns based on 1961 census

[b] number of towns based on 1971 census

[c] number of towns based on 1981 census

Source

CEA. 1996. **Public Electricity Supply, All India Statistics, General Review, 1995/96**. pp. 208-209. New Delhi: Central Electricity Authority. 214 pp.

For more details, please see TEDDY ONLINE+ [Section: Power (rural)]

Table 1.81 Cost structure (paise/kWh of sale) of state electricity boards: 2000/01

State electricity board / Agency	*Fuel*	*Power purchase*	*Operation and maintenance*	*Establishment/ administration*	*Miscellaneous expenses*	*Depreciation*	*Interest*	*Total*
Andhra Pradesh	82.45	256.20	12.35	34 74	5 08	22.10	75 16	488.08
Assam	56.87	168.26	15.31	127.60	10.37	44.14	119 10	541.65
Bihar	24.73	193 16	11 59	86.67	0	22 01	12.76	350.92
Delhi Vidyut Board	40 95	325.08	20.47	36.99	0	18.18	17.85	459.52
Gujarat	101.80	141.16	6 80	35.74	0	21.63	28.50	335.58
Haryana	201.40	250.57	16 40	73.20	-2.82	29.36	75.88	644.01
Himachal Pradesh	0	69.85	25 32	68.39	0	7.77	47.42	218.75
Jammu and Kashmir	1.40	240.72	6 27	32.09	0	14.61	45.93	341.02
Karnataka	12 48	204.22	8.55	46.87	1.84	18.04	28.67	320.67
Karnataka Power Corporation	59.66	0	3.44	10.69	2.20	15.12	21.02	112.13
Kerala	27.61	125.37	5.37	46.80	5.08	16.35	49.38	275 96
Madhya Pradesh	52.75	103.39	10.68	44.82	6.26	17.35	37 11	272.36
Maharashtra	65.08	93.26	13.46	32.29	11.76	24.47	32 81	273.13
Meghalaya	0	22.47	30.78	119.25	0	30.87	64.29	267.66
Orissa	40.80	121.93	15.41	27.40	3.19	44.71	46 30	299.74
Punjab	74.18	42.87	9 46	50 20	0	19.49	50.97	247.17
Rajasthan	63.53	134.46	8 53	31.99	26.64	23.01	46.29	334.45
Tamil Nadu	88.98	89.89	5.76	47.25	1.90	18.69	23.17	275.64
Uttar Pradesh	49 41	85 78	15.74	40.12	0.39	28.80	73.36	293.60
West Bengal	36.57	193.31	10 79	40.13	7 59	16.03	38.29	342.71
West Bengal Power Development Corporation	98 41	0	8 05	6.10	1.30	21.95	30.61	166.42
Average	50.59	138 53	9.99	40.89	5 00	19.88	38.98	303.86

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 101
New Delhi: Power and Energy Division, Planning Commission, Government of India.

For more details, please see TEDDY ONLINE+ [Section: Power (finance-costs and revenues)]

Table 1.82 Unit cost of power supply (paise/kWh): 1991/92 to 2000/01

State electricity board / Agency	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[b]
Andhra Pradesh										
APSEB/APTRANSCO	89.23	100.07	109.00	128.93	156.12	213.83	239.69	287.72	295.50	353 31
APGENCO	–	–	–	–	–	–	–	–	126.76	134.76
Assam	281.24	255.22	252.65	299.30	356.07	337 32	457.17	297.48	511.38	541.66
Bihar	176.53	185.67	200.05	232.84	252.40	290.55	316.04	299.15	318.54	350.93
Delhi Vidyut Board	144.06	164.12	–	–	329 76	360.87	384.66	458.46	490.12	459.53
Gujarat	132.28	146.59	158.40	171.63	181.53	207.41	247.62	276.57	307.66	335.59
Haryana	115.47	134.40	165.40	179.53	208.69	240.64	293.40	313.72	343.07	359.98
Himachal Pradesh	118 19	114.31	142.80	126 60	111.45	142.96	166.01	193.08	204.19	218.75
Jammu and Kashmir	172.34	165 46	209.13	230.80	242.48	286.24	293.01	325.26	347.44	341.01
Karnataka	92.02	96.77	112.10	121.11	152.34	187.25	179.37	239.23	255.53	320.65
Karnataka Power Corporation	30.97	42.64	43 58	41.92	69.75	88.51	74.24	80.36	92.40	112 12
Kerala	81.30	87.30	98.32	108.84	134.46	161.29	196.01	179.24	244.19	275.96
Madhya Pradesh	121.53	141.44	157.80	167.18	181.64	216.18	231.46	250.59	260.83	272.38
Maharashtra	124.51	138.95	152.24	162.02	185.25	206 87	215.58	223.35	261.24	273.13
Meghalaya	107.06	110.09	97.75	139.01	147.35	159 63	179 88	220.65	229.87	267.66
Orissa	71.77	98.80	133.46	185 70	227.46	322.60	351.73	350.75	184.19	177.45
Punjab	98.77	122 00	145.16	165.06	179 69	187.34	217.18	235.74	247 15	247.17
Rajasthan	113.31	138.24	163.80	196.52	213.17	234.55	258 60	287.87	334 58	334.45
Tamil Nadu	103 33	124.52	144.72	152.02	170.91	185.02	208.12	229.16	253.09	275.64
Uttar Pradesh	119.51	153.42	169.44	177.53	191 98	222.28	253.31	267.71	288 09	293 59
West Bengal	163.69	161.90	170.05	185.21	189.39	205.36	252.48	300.36	318.42	342.71
West Bengal Power Development Corporation	73.12	82.90	90.40	110.34	109.03	136.54	160.01	151.16	143 88	166 42
Average	116.80	128.15	149.12	163.40	179.60	215.78	240.20	262.93	283.67	303.86

[a] revised

[b] Annual Plan

Source

Planning Commission 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments** p. 96. New Delhi: Power and Energy Division, Planning Commission, Government of India

For more details, please see TEDDY ONLINE+ [Section: Power (finance-costs and revenues)]

Table 1.83 Consumer categorywise average tariff of electricity (paise/kWh): 2000/01

State electricity board / Agency	*Domestic*	*Commercial*	*Agriculture/ irrigation*	*Industrial*	*Railway traction*	*Outside state*	*Overall average*
Andhra Pradesh	174.0	426 0	14.0	399.2	420.0	0	182.0
Assam	146.5	416.6	233.2	361.4	0	0	353.2
Bihar	109.4	223.2	12.2	275.4	330.0	190.6	200.1
Delhi	273.9	401.5	276.0	367.4	0	0	320.0
Gujarat	246.0	430.0	17.0	434.7	510.0	0	225.0
Haryana	280.0	430.0	29.5	445.1	–	–	214.9
Himachal Pradesh	92.5	234.4	50.0	232.5	0	225.0	203.0
Jammu and Kashmir	125.0	230.0	250.0	200.0	0	0	194.2
Karnataka	249.0	680.0	108.7	438.1	481.0	0	252.9
Kerala	104.0	458.3	59.6	278.2	151.0	0	236.7
Madhya Pradesh	120.4	410.4	11.1	410.6	530.3	265.4	166.7
Maharashtra	178.0	417.8	24.6	202.2	371.5	250.0	231.2
Meghalaya	130.8	205.9	52.0	202.2	0	169.1	174.2
Orissa	–	–	–	–	–	0	157.9
Punjab	190.2	338.5	–[a]	283.2	0	205.0	176.4
Rajasthan	138.0	310.0	34.9	321.9	331.0	221.9	195.8
Tamil Nadu	197.7	397.6	1.2	385.2	379.5	129.8	233.5
Uttar Pradesh	129.5	313.3	50.0	423.4	421.0	19.1	183.4
West Bengal	162.6	245.2	53.8	347.0	400.9	374.3	240.7
Average	174.2	341.2	28.4	360.2	420.8	194.8	212.0

[a] free supply

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 125. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.84 Average tariff for sale of electricity (paise/kWh): 1991/92 to 2000/01

State electricity board / Agency	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[b]
Andhra Pradesh	83.29	94.28	98.62	92.90	97.10	156 00	166.65	165.54	177.00	182 00
Assam	92 11	120.96	121.30	121.50	203.31	205.61	215.81	245.72	312.09	353.16
Bihar	97.82	118.36	147.40	155.00	178.76	185.20	200 80	200.14	200.14	200.14
Delhi	124.67	134.00	–	–	232.70	248.56	323.97	264.33	283.78	320 00
Gujarat	93.00	100.32	121.02	128 00	132.00	163.00	184 00	190.00	206 00	225.00
Haryana	66.33	72.54	83.30	110.80	132.80	155.28	187.36	199.55	214.74	214.91
Himachal Pradesh	85.95	101.14	106.80	116.30	121.40	143.45	162.32	173.82	192.06	203.04
Jammu and Kashmir	35.93	35.26	35.10	36.70	35.60	34.02	34.35	66.67	156.36	194 16
Karnataka	82.38	93.35	106.80	105.10	114.40	140 55	152.20	192.20	204.89	252 88
Kerala	60 00	73 96	82.10	86.70	92.80	95.61	124.60	130.83	187.50	236.66
Madhya Pradesh	94.88	118.88	118.90	129 60	139.40	176 48	170.36	156.34	159.94	166 74
Maharashtra	107.80	136.90	150.50	161.10	169.00	199.03	208.81	215.61	229.70	231.18
Meghalaya	64 60	89.50	91.40	98.90	107.20	127.74	129.14	129.16	131.40	174.18
Orissa	65.13	77.15	95.10	149 80	175.36	235.02	259.04	255.59	138.73	157.87
Punjab	59.88	70.30	89.30	108.30	124 90	136.07	147.80	157.80	171.59	176.42
Rajasthan	93.12	105.10	115.30	133.30	142.30	165.53	187.89	187.89	194 38	195 79
Tamil Nadu	96.09	107.10	128 30	150.20	165.90	172 88	194.63	198.51	209.10	233.49
Uttar Pradesh	79.73	108.40	111.80	122.40	140.00	142.98	171.56	180.61	182.02	183.35
West Bengal	111.86	115.70	135 40	143.00	147 90	151.60	182.02	183.81	223.36	240.72
Average	89.06	105 40	116 70	128.00	139.00	165.74	180.85	185.75	199.13	212.00

[a] revised

[b] Annual Plan

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 120. New Delhi: Power and Energy Division, Planning Commission, Government of India.

For more details, please see TEDDY ONLINE+ [Section: Power (finance tariff)]

Table 1.85 Revenue arrears receivable by state electricity boards (million rupees): 1994/95 to 1997/98

	Total				*As % of sales revenue*			
State electricity board	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Andhra Pradesh	4 569	4 568	5 667	7 320	21.3	20.0	17.2	18.3
Assam	1 304	1 812	2 352	2 837	47.9	49.4	58.4	69.0
Bihar	13 257	18 029	14 291	17 327	134 2	154.1	112.6	118.0
Delhi	–	21 920	–	–	–	140.5	0	0
Gujarat	7 200	8 490	10 310	11 560	26.1	26.0	24.7	23.4
Haryana	2 687	3 788	5 144	7 398	29.7	32.6	36.6	44.5
Himachal Pradesh	540	462	595	699	22.2	15.9	16.6	16.1
Jammu and Kashmir	1 124	1 261	1 405	1 259	182.8	227.7	227.1	143.2
Karnataka	5 920	6 713	7 601	10 465	35.4	36.8	35.6	39.1
Kerala	1 705	1 856	7 601	10 465	28.0	27.0	113.2	109.6
Madhya Pradesh	5 775	7 332	10 452	13 771	21.3	22.1	25.0	33.1
Maharashtra	16 410	18 400	22 190	25 730	27.0	26.2	26.1	28.1
Meghalaya	0	667	799	1 025	0	122.3	137.8	144.0
Orissa	0	0	3 733	6 530	0	0	32.6	47.5
Punjab	1 822	2 034	2 475	3 039	10.5	9.9	10.2	10.9
Rajasthan	2 549	3 427	2 475	3 039	15.6	17.3	10.4	10.3
Tamil Nadu	1 029	846	940	983	3.0	2.1	2.1	1.9
Uttar Pradesh	17 850	25 569	30 052	37 379	56.5	69.5	77.7	80.3
West Bengal	6 400	7 840	8 285	11 531	58.6	58.9	58.0	63.8
Total	90 141	135 014	136 364	172 357	29.8	36.4	31.0	33.8

Source

Planning Commission. 2000. **Annual Report on the Working of State Electricity Boards and Electricity Departments**. p. 156. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.86 Effective subsidy for agricultural consumers (million rupees): 1992/93 to 2000/01

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[b]
Andhra Pradesh	7 260	9 250	13 500	17 480	15 707	20 872	27 087	31 242	39 394
Assam	60	9	110	90	71	-4	94	163	199
Bihar	2 680	2 520	2 970	3 000	3 507	4 507	5 081	5 755	6 841
Delhi	90	0	0	0	0	0	0	436	162
Gujarat	10 550	12 060	12 660	16 470	18 872	24 700	31 722	38 780	43 965
Haryana	4 570	5 400	4 900	6 120	7 697	8 928	10 654	13 122	15 617
Himachal Pradesh	10	20	10	10	11	12	17	22	25
Jammu and Kashmir	280	530	670	710	929	1 232	1 376	637	455
Karnataka	4 970	6 680	8 710	11 090	12 501	15 300	15 114	19 429	17 044
Kerala	0	160	230	360	442	482	492	827	1 161
Madhya Pradesh	4 210	7 560	11 040	14 160	17 945	21 846	28 749	30 666	33 688
Maharashtra	10 310	11 310	16 470	22 500	25 559	29 860	30 875	38 673	42 899
Meghalaya	0	0	0	0	2	2	1	1	1
Orissa	210	390	200	300	400	518	664	–	–
Punjab	6 870	7 970	7 810	8 290	10 086	0	0	0	0
Rajasthan	3 480	4 680	6 230	8 080	9 632	11 157	12 614	17 980	17 265
Tamil Nadu	6 430	7 600	9 470	11 330	12 254	15 025	17 231	20 387	23 026
Uttar Pradesh	10 350	12 270	12 750	14 020	17 621	19 256	21 781	24 048	25 273
West Bengal	1 040	1 150	1 690	2 070	2 567	3 374	3 301	3 243	3 819
Total	73 350	89 660	109 410	136 060	155 852	177 067	206 854	245 409	270 835

[a] revised
[b] Annual Plan

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 136. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.87 Subsidy for domestic consumers (**million rupees**): 1992/93 to 2000/01

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[b]
Andhra Pradesh	404	636	1 187	1 593	2 711	3 361	6 431	7 113	12 351
Assam	372	824	793	901	1 276	1 887	1 737	2 553	2 960
Bihar	400	563	892	1 189	1 583	1 812	1 996	2 334	2 897
Delhi	2 974	0	0	0	0	0	0	10 945	8 449
Gujarat	880	949	1 218	1 361	1 314	2 016	2 347	2 773	2 747
Haryana	956	1 372	1 132	1 231	1 278	1 629	1 481	1 348	1 934
Himachal Pradesh	137	259	232	199	354	503	694	790	851
Jammu and Kashmir	495	620	700	938	1 327	1 707	2 301	2 178	2 326
Karnataka	225	92	353	1 185	1 601	424	1 679	1 599	2 803
Kerala	605	834	1 147	2 040	3 456	4 398	4 508	6 880	10 108
Madhya Pradesh	2 527	2 584	3 154	4 015	5 386	6 350	7 593	6 647	7 820
Maharashtra	1 516	1 933	1 902	3 267	3 803	3 407	3 469	5 758	6 693
Meghalaya	14	11	28	59	75	117	174	160	183
Orissa	804	1 224	921	1 435	2 824	3 417	3 590	–	–
Punjab	543	831	1 081	1 196	1 618	2 313	2 054	2 263	2 450
Rajasthan	1 833	1 275	1 634	2 207	2 426	3 237	3 950	5 243	5 633
Tamil Nadu	1 418	1 476	1 586	1 927	2 374	2 172	2 840	4 374	4 618
Uttar Pradesh	3 318	4 685	5 635	5 575	8 069	10 790	12 672	14 190	15 264
West Bengal	929	1 140	1 773	1 926	2 385	3 046	4 814	3 893	4 575
Total	20 349	21 308	25 368	32 244	43 860	52 584	64 330	81 040	94 663

[a] revised

[b] Annual Plan

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 139. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.88 Cross-subsidy from other users (**million rupees**): 1992/93 to 1999/2000

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*[a]	*1999/2000*[b]
Andhra Pradesh	6680	7815	6497	5328	6805	8932	6868	7091
Assam	1480	1154	1293	1729	−1499	−2421	−1603	−1689
Bihar	660	187	1061	557	−2060	−1993	−1424	−1706
Delhi	710	0	0	0	0	0	−5954	−2492
Gujarat	3190	5386	4507	5659	7922	16775	21045	26180
Haryana	230	422	800	1515	1813	1316	184	−629
Himachal Pradesh	67	221	52	322	297	551	337	559
Jammu and Kashmir	1180	1650	2102	1995	−2859	−3093	−3042	−1728
Karnataka	4750	5987	6516	6268	7132	10930	10836	18654
Kerala	15	16	181	179	−620	−514	282	4215
Madhya Pradesh	3100	4453	6519	9623	15056	13406	11475	8586
Maharashtra	11350	12624	17814	19007	30664	30909	32677	31444
Meghalaya	3	52	47	42	−52	−76	−181	−206
Orissa	1667	688	518	750	−513	−512	−959	454
Punjab	350	556	375	823	2641	2448	2031	3666
Rajasthan	870	651	391	1331	2493	3526	6108	3145
Tamil Nadu	4610	5876	10799	12132	10851	13538	12095	16803
Uttar Pradesh	9200	3948	4839	6007	4763	8209	10088	10742
West Bengal	864	30	115	575	−234	−167	334	1252
Total	39110	45225	53792	63337	82601	101763	101199	124343

[a] revised

[b] Annual Plan

Source

Planning Commission. 2000. **Annual Report on the Working of State Electricity Boards and Electricity Departments**. p. 145. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.89 Subsidy to sales revenue ratio (with cross-subsidization) (%): 1992/93 to 2000/01

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*^{a}	*2000/01*^{b}
Andhra Pradesh	6.1	10.5	38.8	60.8	36.9	43.8	74.1	66.7	94.3
Assam	111.0	101.4	85.7	74.9	69.3	111.8	75.5	62.5	52.2
Bihar	56.9	36.1	50.6	41.2	56.9	57.6	49.5	59.5	75.7
Delhi	22.4	0	0	0	0	0	0	0	0
Gujarat	46.1	30.5	34.0	37.2	27.1	34.5	45.4	49.7	50.4
Haryana	85.3	98.5	62.6	55.8	55.0	56.6	58.1	–	–
Himachal Pradesh	13.0	33.8	8.9	-6.1	8.9	11.2	21.0	15.1	16.1
Jammu and Kashmir	348.4	504.8	874.1	657.0	826.5	700.5	834.3	407.7	286.9
Karnataka	3.7	5.0	15.2	32.9	33.2	19.1	37.2	23.5	26.8
Kerala	18.1	19.8	25.6	37.4	68.7	57.3	37.0	30.2	17.2
Madhya Pradesh	19.0	24.0	29.0	26.1	22.5	35.9	60.3	63.1	63.4
Maharashtra	1.5	1.1	0.6	9.6	3.9	3.2	2.5	12.7	16.9
Meghalaya	24.2	6.9	40.5	37.6	21.0	39.3	70.9	74.9	53.5
Orissa	28.0	40.4	24.0	29.5	38.7	36.7	35.1	–	–
Punjab	71.7	61.8	49.9	43.4	36.7	-0.4	-4.9	-2.7	-3.0
Rajasthan	31.5	42.0	47.4	47.6	38.3	33.5	49.9	54.9	44.2
Tamil Nadu	16.1	12.8	1.2	3.0	7.0	6.9	15.4	21.0	18.1
Uttar Pradesh	41.6	51.5	45.0	39.2	55.5	47.7	48.2	58.3	60.1
West Bengal	39.9	27.6	35.7	27.4	38.8	37.1	62.8	41.6	41.5
Average	25.6	27.0	28.2	29.1	45.8	28.2	36.0	39.3	41.0

[a] revised

[b] Annual Plan

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 146. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.90 Sales revenue as a ratio of cost (%): 1992/93 to 2000/01

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[b]
Andhra Pradesh	94.2	90.5	72.1	62.2	73.1	69.5	57.4	60.0	54.5
Assam	47.4	49.7	53.9	57.1	62.8	47.2	57.0	61.0	65.2
Bihar	63.7	73.5	66.4	70.8	63.7	63.4	66.9	62.8	57.0
Delhi	81.7	0	0	70.6	72.0	72.6	63.9	65.6	69.6
Gujarat	68.4	76.6	74.6	72.9	75.4	74.3	68.7	66.8	67.2
Haryana	54.0	50.4	61.5	63.6	64.5	63.9	63.6	62.6	59.7
Himachal Pradesh	88.5	74.5	91.9	98.8	91.8	89.9	82.6	86.9	86.1
Jammu and Kashmir	21.3	16.7	10.3	13.2	10.9	12.5	10.7	19.7	25.9
Karnataka	96.5	95.3	86.8	74.9	75.1	84.0	73.4	80.2	78.9
Kerala	84.7	83.5	79.6	69.0	59.3	63.6	73.0	76.8	85.8
Madhya Pradesh	84.0	80.7	77.3	79.5	81.6	73.6	62.4	61.3	61.2
Maharashtra	98.5	88.8	99.4	91.2	96.2	96.9	96.6	88.7	85.5
Meghalaya	81.3	93.6	71.2	72.7	78.6	71.8	58.5	57.2	65.1
Orissa	78.1	71.2	80.7	77.1	72.8	73.6	72.9	74.2	89.0
Punjab	57.6	61.8	66.7	69.7	73.2	68.1	67.2	69.4	71.4
Rajasthan	76.0	70.4	67.8	67.8	71.9	74.5	66.4	64.0	69.2
Tamil Nadu	86.0	88.7	98.8	97.1	93.4	93.5	86.6	82.6	84.7
Uttar Pradesh	70.6	66.0	69.0	70.7	64.3	67.7	67.5	63.2	62.5
West Bengal	71.5	73.4	73.7	78.5	72.1	73.2	61.2	70.2	70.2
Average	82.2	78.3	78.3	76.1	76.8	76.0	70.9	70.4	70.0

[a] revised

[b] Annual Plan

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments**. p. 128. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.91 Percentage of unit cost of supply recovered from the consumer tariff by category: 1999/2000

State electricity board	*Domestic*	*Commercial*	*Agriculture/ irrigation*	*Industrial*	*Railway traction*	*Outside state*	*Overall average*
Andhra Pradesh	49.25	120.57	3.96	112.99	118.88	0	51.51
Assam	27.04	76.91	43.05	66.72	0	0	65.21
Bihar	31.16	63.60	3.49	78.48	94.04	54.31	57.03
Delhi	59.60	87.37	60.06	79.95	0	0	69.64
Gujarat	73.30	128.13	5.07	129.53	151.97	0	67.05
Haryana	77.78	119.45	8.19	123.65	0	0	59.70
Himachal Pradesh	42.29	107.15	22.86	106.29	0	102.86	92.80
Jammu and Kashmir	36.66	67.45	73.31	58.65	0	0	56.95
Karnataka	77.65	212.07	33.89	136.63	150.01	0	78.87
Kerala	37.69	166.07	21.60	100.81	54.72	0	85.77
Madhya Pradesh	44.20	150.67	4.08	150.75	194.69	97.44	61.20
Maharashtra	65.17	152.97	9.01	74.03	136.02	91.53	84.65
Meghalaya	48.87	76.93	19.43	75.54	0	63.18	65.08
Orissa	0	0	0	0	0	0	88.98
Punjab	76.93	136.95	0	114.58	0	82.94	71.37
Rajasthan	41.26	92.69	10.42	96.25	98.97	66.35	58.54
Tamil Nadu	71.73	144.25	0.44	139.75	137.68	47.09	84.71
Uttar Pradesh	44.11	106.71	17.03	144.21	143.40	6.52	62.47
West Bengal	47.44	71.55	15.70	101.25	116.98	109.22	70.23
Average	57.33	112.29	9.35	118.54	138.48	64.11	69.77

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.92 Number of consumers **(thousands)** and connected load **(MW)**: 1990/91 to 1997/98

Category	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Number of consumers								
Domestic	50 389.3	53 771.3	56 664.2	60 193.2	63 409.3	66 984.1	69 942.2	74 583.0
Commercial	8 002.1	8 429.3	8 772.5	9 209.2	9 558.2	9 971.1	10 413.9	10 719.8
Industrial (low- and medium-tension)	2 042.3	2 144.4	2 206.7	2 301.6	2 382.0	2 425.5	2 390.7	2 513.7
Industrial (high-tension)	34.7	35.6	41.7	35.5	40.7	43.6	48.5	50.0
Public lighting	278.5	275.8	278.2	297.6	298.9	332.4	321.4	325.6
Traction	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Agriculture	8 631.0	9 128.3	9 558.2	9 971.1	10 372.0	10 762.2	11 286.5	11 497.8
Public water works	123.9	134.1	144.0	161.0	171.0	183.4	197.3	207.9
Miscellaneous	130.8	268.5	270.0	142.8	166.4	319.7	335.9	460.4
Total	69 632.8	74 187.5	77 935.7	82 312.2	86 398.7	91 022.3	94 936.6	100 358.6
Connected load								
Domestic	32 051.2	38 979.0	46 183.0	49 254.5	51 589.7	55 643.2	59 154.8	63 500.6
Commercial	8 340.8	8 730.6	10 701.7	11 799.9	12 123.0	12 973.8	14 728.2	14 414.9
Industrial (low- and medium-tension)	20 477.2	23 016.4	23 736.0	24 404.3	24 592.9	25 428.4	26 231.9	28 065.6
Industrial (high-tension)	22 469.5	23 949.3	26 184.1	28 034.2	29 642.2	31 970.3	33 686.8	34 871.8
Public lighting	632.6	686.1	765.9	768.3	787.8	828.8	976.8	1 013.3
Traction	1 563.0	1 672.6	2 027.2	1 981.2	2 300.4	2 147.5	2 309.5	2 384.5
Agriculture	32 511.5	34 562.3	36 399.9	38 556.0	40 108.3	42 166.0	45 017.5	46 484.3
Public water works	1 680.4	2 093.0	2 236.7	2 110.3	2 108.3	2 231.2	2 654.9	2 710.3
Miscellaneous	1 175.1	1 975.5	1 561.7	2 034.0	2 248.4	1 951.3	2 289.2	2 548.8
Total	120 901.3	135 664.8	149 796.2	158 942.7	165 501.0	175 340.5	187 049.5	195 994.2

Note

All figures pertain to 31 March of the respective years.

Sources

1 CEA. 1995. **Public Electricity Supply, All India Statistics, General Review, 1993/94**. pp. 196-200. New Delhi: Central Electricity Authority. 214 pp.

2 CEA. 1997. **Public Electricity Supply, All India Statistics, General Review, 1995/96**. pp. 196-200. New Delhi: Central Electricity Authority. 214 pp.

3 CEA. 1999 **Public Electricity Supply, All India Statistics, General Review, 1996/97**. pp. 202-206. New Delhi: Central Electricity Authority. 220 pp.

4 CEA. 1999. **Public Electricity Supply, All India Statistics, General Review, 1997/98**. pp. 203-207. New Delhi: Central Electricity Authority 221 pp.

For more details, please see TEDDY ONLINE+ [Section: Power (utilization)]

Table 1.93 Commercial profit/loss (Rs crore) for state electricity boards (with subsidy): 1992/93 to 2000/01

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[b]
Andhra Pradesh	−43	−227	−373	39	−885	−13 756	−26 248	−26 752	−38 554
Assam	−2 054	−1 973	−2553	−2 607	−2 442	−4 391	−3 265	−3 575	−3 669
Bihar	−2 796	−1 897	−1889	−2 114	−4 416	−4 949	−5 135	−6 798	−10 810
Delhi	−2 073	–	–	−5 780	−6 264	−7 602	−12 086	−12 093	−11 864
Gujarat	1 000	920	1060	1 080	1 110	1 190	1 260	−13 670	−14 460
Haryana	−3 683	−4 469	−129	460	67	−322	−4 750	−5 323	−8 195
Himachal Pradesh	16	−506	194	107	−193	−330	−867	−674	−836
Jammu and Kashmir	−2 245	−2 932	−3467	−3 632	−5 072	−6 606	−8 343	−8 128	−8 584
Karnataka	322	339	431	512	541	585	670	758	−2 163
Kerala	−653	−750	−1203	−1 300	−1 765	−1 990	−2 052	−2 667	−2 867
Madhya Pradesh	−1 129	381	−795	−80	−1 634	−8 122	−16 642	−18 615	−22 008
Maharashtra	1 616	1 890	2760	2 217	1 665	2 948	5 134	−9 602	−3 581
Meghalaya	−19	37	−135	119	−69	−171	−369	−4 226	−362
Orissa	260	299	249	269	−3 634	−3 864	−3 626	−3 288	−899
Punjab	−6 263	−6 932	−6806	−6 437	−6 034	−9 433	−13 138	−13 046	−13 089
Rajasthan	221	104	771	808	632	654	658	−15 123	−13 521
Tamil Nadu	924	2 255	3478	3 392	3 296	2 736	−5 146	−9 772	−9 567
Uttar Pradesh	−8 075	−12 015	850	3 808	−18 213	−18 531	−19 620	−25 436	−27 840
West Bengal	−2 575	−1 580	−2421	−2 401	−3 432	−4 024	−10 400	−8 041	−9 332
Total	−27 249	−27 056	−9980	−11 777	−46 743	−75 979	−123 968	−182 261	−202 203

[a] revised

[b] Annual Plan

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 129. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.94 Commercial profit/loss (**Rs crore**) for state electricity boards (without subsidy): 1992/93 to 2000/01

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[b]
Andhra Pradesh	–43	–228	–9 814	–12 552	–9 389	–13 756	–22 248	–27 551	–46 054
Assam	–2 054	–1 973	–2 553	–2 612	–2 442	–43 391	–3 265	–3 575	–3 669
Bihar	–2 796	–1 897	–1 889	–2 114	–4 416	4 949	–5 135	–6 797	–10 809
Delhi	–2 073	–	–	–5 780	–6 264	–7 602	–12 086	–12 093	–11 864
Gujarat	–5 190	–493	5 500	–10 030	–9 520	–13 640	–19 670	–25 770	–27 770
Haryana	–4 036	–5 099	–4 679	–5 538	–6 350	–7 647	–8 390	–8 128	–12 421
Himachal Pradesh	–17	–506	194	106	193	–330	–867	–674	–836
Jammu and Kashmir	–2 245	–2 932	–3 467	–3 632	–5 072	–6 606	–8 343	–8 128	–8 584
Karnataka	–194	–19	1 642	–5 024	–6 518	–3 217	–7 916	–7 818	–10 949
Kerala	–653	–750	–1 289	–1 832	–2 080	–1 990	–2 052	–2 667	–2 867
Madhya Pradesh	–4 929	–3 771	–5 942	–6 019	–4 640	–10 576	–19 466	–21 734	–25 438
Maharashtra	1 616	1 890	2 760	–4 082	–921	–1 077	1 583	–9 602	–3 581
Meghalaya	–84	–33	–205	–199	154	–261	–460	–523	–467
Orissa	–854	–1 961	–1 361	–2 307	–3 749	–3 917	–3 656	–3 328	–899
Punjab	–6 263	–6 932	–6 806	–6 437	–6 034	–9 433	–13 138	–13 041	–13 089
Rajasthan	–2 595	–4 145	4 122	–4 299	–4 975	–6 395	–10 871	–15 123	–13 521
Tamil Nadu	–2 576	–3 016	–24	–767	–2 570	–2 964	–7 648	–12 272	–12 067
Uttar Pradesh	–8 075	–12 015	–11 520	–11 362	–33 783	–36 920	–41 195	–41 549	–45 311
West Bengal	–2 575	–2 312	–3 392	–3 218	–3 982	–4 924	–10 890	–8 591	–9 932
Total	–45 603	–50 599	–61 252	–87 696	–113 049	–139 627	–199 716	–230 280	–260 131

[a] revised

[b] Annual Plan

Source

Planning Commission 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 135. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.95 State electricity boards' rate of return on capital (%) (with subsidy): 1992/93 to 2000/01

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[b]
Andhra Pradesh	−0.2	−0.6	−0.8	0.1	−2.06	−33.95	−58.16	−126.90	−139.84
Assam	−43.3	−47.3	−25.7	−32.1	−25.35	−39.81	−40.65	−26.89	−29.60
Bihar	−20.0	−12.7	−19.0	−12.9	27.57	32.56	−35.29	−47.88	−52.96
Delhi	−26.2	–	–	−29.9	−27.75	−29.96	−40.71	−31.14	−71.83
Gujarat	3.2	2.7	2.7	2.7	2.64	2.60	2.58	−27.55	−26.93
Haryana	−23.8	−27.5	−0.8	2.6	0.41	−2.02	−18.72	−23.59	−29.05
Himachal Pradesh	0.5	−14.9	−2.5	2.6	3.74	1.91	−4.75	−1.58	−3.10
Jammu and Kashmir	−39.1	−86.1	−51.7	−48.2	−56.65	−53.18	−60.25	−50.92	−50.23
Karnataka	3.3	3.0	3.0	3.0	3.00	3.00	3.00	3.00	−9.90
Kerala	−11.4	−11.4	−16.7	−17.1	−16.22	−17.05	−11.98	−9.26	−7.98
Madhya Pradesh	−3.4	1.0	−8.6	−0.2	−3.87	−19.89	−42.70	−47.63	−46.93
Maharashtra	3.1	3.1	4.1	2.9	2.16	3.88	6.17	−10.72	−4.16
Meghalaya	−1.8	4.4	−3.6	−5.7	−3.27	−8.44	−17.17	−19.98	−16.43
Orissa	2.6	2.1	1.9	2.5	−18.57	−20.00	−16.96	−29.18	−7.78
Punjab	−19.9	−20.9	−19.4	−21.1	−18.27	−33.21	−45.77	−38.59	−31.81
Rajasthan	1.0	0.4	0	3.0	2.44	2.34	2.35	−52.60	−33.60
Tamil Nadu	3.2	7.3	9.4	8.4	7.79	4.56	−8.15	−14.45	−13.39
Uttar Pradesh	−16.7	−17.8	−12.2	3.2	−14.09	−13.21	−13.47	−15.38	−15.35
West Bengal	−35.3	−20.3	−30.7	−41.8	−36.40	−37.05	−87.98	−62.63	−66.67
Average	−7.6	−6.6	−5.7	−2.2	−7.93	−12.30	−18.78	−26.34	−27.13

[a] revised
[b] Annual Plan

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 151. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.96 State electricity boards' rate of return on capital (%) (without subsidy): 1992/93 to 2000/01

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[b]
Andhra Pradesh	–0.2	–0.6	–22.3	–28.8	–21.80	–33.90	–58.20	–130.69	–167.04
Assam	–43.3	–47.3	–25.7	–32.1	–27.50	–42.53	–32.30	–31.48	–32.30
Bihar	–20.0	–12.7	–19.0	–12.9	–27.57	–32.57	–35.30	–47.88	–65.76
Delhi	–26.2	–	–	–29.9	–27.75	–29.96	–40.70	–33.97	–63.38
Gujarat	–16.5	–14.6	–14.3	–24.9	–22.89	–29.79	–39.90	–51.97	–49.39
Haryana	–26.1	–31.2	–27.9	–31.8	–38.97	–47.79	–53.60	–41.85	–44.03
Himachal Pradesh	0.5	–14.9	–2.5	2.6	–3.77	–5.21	–11.90	–8.56	–9.38
Jammu and Kashmir	–39.1	–50.1	–51.7	–48.2	–56.69	–59.87	–67.00	–57.62	–56.94
Karnataka	–2.0	–0.2	–11.4	–29.4	–36.16	–16.50	–35.45	–30.92	–39.24
Kerala	–11.4	–11.4	–17.9	–24.1	–19.11	–17.10	–11.98	–9.26	–7.98
Madhya Pradesh	–14.6	–9.6	–13.5	–14.3	–10.99	–25.90	–49.94	–55.61	–54.24
Maharashtra	3.1	3.1	4.1	–5.3	–1.20	–0.14	1.89	–10.72	–4.16
Meghalaya	–7.9	–·4	–6.9	–9.6	–7.30	–12.86	–21.35	–24.71	–21.22
Orissa	–8.7	–13.5	–10.2	–21.5	–19.12	–20.28	–19.23	–29.53	–7.78
Punjab	–19.9	–20.9	–19.4	–21.1	–18.18	–31.99	–44.47	–37.58	–31.33
Rajasthan	–11.4	–17.9	–19.1	–16.0	–19.20	–22.88	–38.89	–52.58	–33.60
Tamil Nadu	–8.8	–9.7	–0.1	–1.9	–5.40	–4.94	–12.11	–18.15	–16.89
Uttar Pradesh	–16.7	–17.8	–12.2	–9.6	–26.14	–26.31	–27.87	–25.132	–24.99
West Bengal	–35.3	–29.7	–42.2	–56.1	–42.24	–45.34	–92.13	–66.92	–70.95
Average	–12.7	–12.3	–13.1	–16.4	–19.57	–22.94	–30.84	–33.78	–35.06

[a] revised
[b] Annual Plan

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 152. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.97 State electricity boards' rate of return on capital (%) (with 50 paise/kWh for agriculture): 1992/93 to 2000/01

State electricity board	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]	*2000/01*[b]
Andhra Pradesh	13.4	9.3	−11.2	−15.7	−12.7	−22.4	−47.1	−104.30	−146.0
Assam	−43.3	−47.3	−25.7	−31.8	−27.3	−42.4	−31.9	−31.20	−32.0
Bihar	−15.7	−9.5	−16.1	−9.0	−23.6	−27.7	−29.2	−41.30	−59.6
Delhi	−26.1	–	–	−29.9	−27.6	−29.8	–	−33.80	−63.1
Gujarat	−6.9	−6.6	−8.1	−12.3	−10.8	−18.0	−27.5	−38.50	−37.1
Haryana	−18.7	−26.1	−26.9	−20.6	−26.4	−35.8	−40.7	−32.60	−35.7
Himachal Pradesh	0.6	−14.8	−2.5	2.7	−3.7	−5.1	−11.8	−8.50	−9.3
Jammu and Kashmir	−37.9	−48.2	−49.9	−46.2	−54.8	−57.9	−64.9	−55.80	−55.3
Karnataka	23.1	25.2	13.1	−7.9	−17	−6.9	−19.8	−14.50	−24.8
Kerala	−10.4	−10.7	−16.9	−22.0	−17.6	−15.6	−10.8	−8.50	−7.2
Madhya Pradesh	−11.9	−5.4	−6.4	−4.8	−0.8	−14.1	−34.9	−39.90	−40.5
Maharashtra	8.7	7.1	9.4	3.3	7.8	10.0	11.4	−1.60	−5.9
Meghalaya	−7.9	−4.0	−6.9	−9.6	−7.3	−12.8	−21.3	−24.70	−21.2
Orissa	−8.1	−12.8	−10.2	−20.7	−18.7	−19.8	−18.6	–	–
Punjab	−12.2	−15.1	−16.8	−11.5	−8.6	−21.7	−31.7	−27.50	−23.0
Rajasthan	−8.7	−15.0	−16.2	−7.9	−10.1	−14.0	−30.0	−42.10	−26.4
Tamil Nadu	0	−1.3	8.3	6.3	1 6	1.1	−6.1	−12.20	−11.0
Uttar Pradesh	−13.5	−15.4	−11.5	−5.5	−22.3	−22.9	−24.5	−22.10	−22.1
West Bengal	−32.2	−27.1	−38.6	−45.3	−35.0	−38.6	−87.0	−62.20	−66.2
Average	−6.6	−6.9	−8.1	−8.5	−12.4	−15.6	−23.5	−26.64	−28.0

[a] revised

[b] Annual Plan

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 153. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.98 Sale of power to consumer by category (MWh): 2000/01

State electricity board / Electricity department	*Domestic*	*Commercial*	*Agriculture/ irrigation*	*Industry*	*Railway traction*	*Outside state/Union Territory*	*Others*	*Total*
State electricity board								
Andhra Pradesh	6 888	1 553	11 610	7 142	1000	0	1 895	30 088
Assam	749	24	64	609	0	0	594	2 040
Bihar	1 199	585	2 020	5 117	600	149	324	9 994
Delhi	4 552	2 005	88	1 890	0	0	1 724	10 259
Gujarat	3 066	940	13 800	10 570	430	0	3 130	31 936
Haryana	2 418	439	4 725	2 097	0	0	911	10 590
Himachal Pradesh	674	162	15	1 434	0	755	396	3 436
Jammu and Kashmir	1 077	250	500	500	0	0	1 070	3 397
Karnataka	3 912	706	8 040	4 035	35	0	1 345	18 073
Kerala	5 878	739	536	4 213	17	0	883	12 266
Madhya Pradesh	5 145	802	12 892	6 780	1446	176	2 631	29 872
Maharashtra	7 036	1 617	17 262	18 700	1180	800	6 305	52 900
Meghalaya	134	41	–	110	0	110	116	511
Orissa	–	–	–	–	–	–	–	–
Punjab	4 297	938	7 000	8 586	0	1300	622	22 743
Rajasthan	2 868	985	5 763	6 593	236	400	815	17 660
Tamil Nadu	5 926	1 792	8 390	11 164	431	227	2 883	30 813
Uttar Pradesh	9 304	2 215	10 374	5 922	895	534	1 290	30 534
West Bengal	2 540	1 183	1 322	2 987	603	17	2 004	10 656
Sub-total	67 663	16 977	104 401	98 450	6873	4468	28 937	327 769
Electricity department								
Arunachal Pradesh	78	12	0	15	0	0	13	118
Goa	259	88	13	749	0	36	62	1 207
Manipur	167	20	20	37	0	0	90	335
Mizoram	105	12	0	2	0	0	19	138
Nagaland	82	10	0	22	0	0	29	143
Pondicherry	202	73	124	942	0	0	32	1 179
Sikkim	62	12	0	9	0	0	18	101
Tripura	219	16	99	14	0	53	50	451
Sub-total	1 173	242	257	1 788	0	89	314	3 863
Total	68 836	17 218	104 659	100 238	6873	4557	29 251	331 632

Source

Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments**. p. 72. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.99 Plan outlay and expenditure (**million rupees**) for power sector

		Outlay			*Expenditure*		
Five-Year Plan	*Period*	*Power sector*	*All sectors*	*% of all sectors*	*Power sector*	*All sectors*	*% of all sectors*
First	1951-56	3 934.4	20 687.6	19.0	2 600.0	19 600 0	13.2
Second	1956-61	4 268.7	48 000.0	8.9	4 454.9	46 000.0	9.6
Third	1961-66	10 197.2	80 945.3	12.6	12 523.0	85 765.0	14.6
Fourth	1969-74	24 475.7	159 021.6	15.4	29 317.0	157 788.8	18.5
Fifth	1974-79	72 939.0	392 874.9	18.6	72 995.0	394 262.0	18.7
Sixth	1980-85	192 654.4	957 000.0	20.1	182 986.8	1 092 914.4	16.7
Seventh	1985-90	342 735.0	1 800 000.0	19.0	378 953.0	2 187 296.0	17.3
Eighth	1992-97	795 893.0	4 341 000.0	18.3	766 773.8	4 854 571.7	15.8
Ninth	1997-02	1 245 260.0	8 592 000.0	14.5	–	–	–
Annual Plan	1997-98	208 305.0	1 559 047.0	13.4	193 963.0	1 297 573.0	14.9
Annual Plan	1998-99	257 380.0	1 859 075.0	13.8	215 590.0	1 494 035.0	14.2
Annual Plan	1999-00	268 250.0	1 922 629.0	14.0	212 682.0	1 708 568.0	12.4
Annual Plan	2000-01	265 544.0	2 033 593.0	13.1	241 997.0	1 879 309.0	12.9

Sources

1 ***Ninth Five-Year Plan, 1997-2002.*** Volume II. **Thematic Issues and Sectoral Programmes.**
New Delhi: Planning Commission, Government of India.

2 Planning Commission. 2001. **Annual Report on the Working of State Electricity Boards and Electricity Departments.** p. 15.
New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 1.100 List of private sector projects commissioned (project-wise since 1991) as on 31 January 2001

Power producer	*Capacity commissioned* (MW)
Private power projects which requires TEC from CEA	
Paguthan CCGT (combined cycle gas turbine) (Gujarat PowerGen Energy Corporation), Gujarat	655.00
Hazira CCGT (Essar Power Ltd), Gujarat	515.00
Baroda CCGT (GIPCL [Gujarat Industries Power Company Ltd]), Gujarat	167.00
Surat Lignite TPP (GIPCL), Gujarat	250.00
Dabhol CCGT (Dabhol Power Co.), Maharashtra	740.00
Jegurupadu CCGT (GVK Industries), Andhra Pradesh	216.00
Godavari CCGT (Spectrum Tech.), Andhra Pradesh	208.00
Basin Bridge DGPP (GMR Vasvi), Tamil Nadu	200.00
Toranagallu TPS (Jindal Tractebel), Karnataka	260.00
Kondapally CCGT (Kondapally Power Corporation Ltd), Andhra Pradesh	350.00
Private power projects which do not require TEC from CEA	
Guntur Branch Canal-I HEP Andhra Pradesh	3.75
Shivpur HEP (Bhoruka Power Company), Karnataka	18.00
Maniyar HEP (Carborandum Universal), Kerala	12.00
Reliance Salgaokar Project, Goa	48.00
Adamtilla GBPP (DLF Power Co. Ltd), Assam	9.00
Bansakandi GBPP (DLF Power Co. Ltd), Assam	15.50
Gurgaon CCGT (Magnum Power), Haryana	25.00
Tawa HEP (Hindustan Electro Graphite), Madhya Pradesh	13.50
Bellary Power projects (FO/LSHS), Karnataka	27.80
Eloor CCGT (BSES Kerala Power), Kerala	173.00
Licencees	
New Southern Gen. Station (CESC Ltd), Calcutta	135.00
Trombay TPP (BSES), Maharashtra	180.00
Dahanu TPP (BSES), Maharashtra	500.00
Bhira PSS (Tata Electric Co.), Maharashtra	150.00
Budge-Budge TPP (CESC Ltd), West Bengal	500.00
Total	5369.75

Source

Data obtained from the Ministry of Power, Government of India, New Delhi (2001)

Table 1.101 Private power projects identified for implementation during Ninth Plan

State / Union Territory	*Name of the project*	*Capacity* (MW)
Andaman and Nicobar Islands	Bamboo Flat DG	20.0
Andhra Pradesh	Godavari CCGT	114.0
Andhra Pradesh	Jegurupadu CCGT	75.5
Andhra Pradesh	Kondapalli CCGT	350.0
Andhra Pradesh	Vemagiri CCGT	468.0
Andhra Pradesh	Gautami CCGT	358.0
Andhra Pradesh	BSES Andhra Power Ltd	200.0
Assam	Adamtilla CBPP	9.0
Assam	Banaskandi GBPP	15.5
Bihar	Jojobera TPP	240.0
Gujarat	Sabarmati TTP	120.0
Gujarat	Hazira CCGT	185.0
Gujarat	Surat Lignite TTP	250.0
Gujarat	Paghuthan CCGT	655.0
Gujarat	Baroda CCGT	167.0
Haryana	Magnum Power	25.0
Haryana	Phoenix power (FO)	175.0
Himachal Pradesh	Baspa HEP	300.0
Karnataka	Torangallu TPP	260.0
Karnataka	Bellary Hospet	27.8
Karnataka	Tanir Bavi	200.0
Karnataka	Bidadi CCGT	200.0
Karnataka	Bharat Forge CCGT	50.8
Karnataka	DLF Power CCGT Tumkur	32.5
Kerala	Bhattahamkettu	16.0
Kerala	Cochin CCGT (BSES)	173.0
Madhya Pradesh	Ratlam DGPP	118.0
Maharashtra	Dabhol Phase-I & Phase-II	2184.0
Rajasthan	Global boards CCGT	130.0
Tamil Nadu	Basin Bridge DGPP	200.0
Tamil Nadu	Samayanallur DGPP	106.0
Tamil Nadu	Pillaiperumalnallur CCGT	330.5
Tamil Nadu	Sampalpatti DGPP	106.0
West Bengal	Budge-Budge TPP	500.0

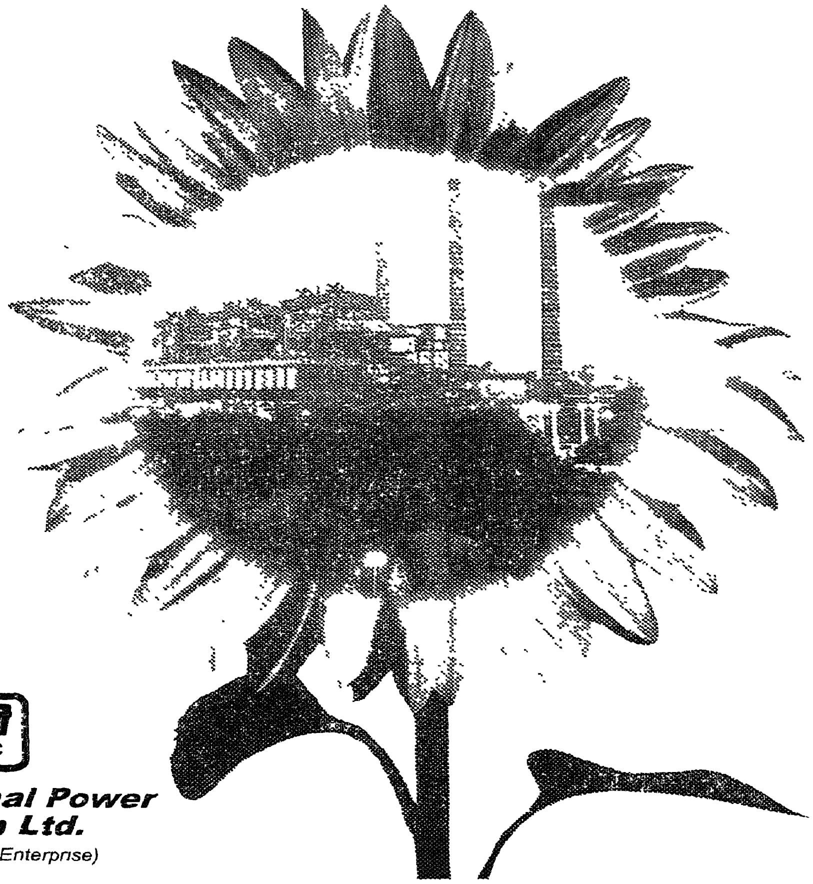
Source

Ministry of Power. 2000. [Unpublished data]

Flowers of envirocare bloom, at all our plants

At NTPC, we believe in leading the way when it comes to environmental care. Nearly one and a half crore trees bloom around our power plants and stand lush green testimony to our environmental activities including regular monitoring programmes, enviro-audits, reviews, renovation, ecological impact studies and afforestation.

India's largest power utility with an installed capacity of 19,435 MW provides about 26% of total power generated in the Country.



एनटीपीसी
NTPC

National Thermal Power Corporation Ltd.
(A Government of India Enterprise)

THE GREEN POWER NAVARATNA

naa/NTPC/123/01

Renewable energy sources and technologies

At a glance

- Over 3165 MW of power generating capacity based on renewable energy sources has been installed. This is about three per cent of the total installed capacity in the country.
- India has the world's largest deployment of solar PV (photovoltaics), consisting of 850 000 PV systems, aggregating 50 MW and encompassing 40 different applications.
- With over 3.22 million biogas plants installed, India is second in the world, China being first.
- India ranks third in annual production capacity of solar PV (17 MW), ahead of Germany, France, and Australia.
- With 1367 MW of installed wind power capacity, India ranks fifth in the world (total installed global wind power capacity: 18 710 MW).
- Over 590 000 square metres of solar collector area installed against re-assessed gross potential of 140 million square metres.
- Gross wind power potential has been re-assessed at 45 000 MW.
- 4096 potential sites with an aggregate capacity of 10 072 MW for small hydropower projects (up to 25 MW) have already been identified.
- A potential of 16 000 MW of power from surplus/distributed biomass material has been estimated.
- There exists a potential of 3500 MW of bagasse-based power from 453 sugar mills in India.
- It is proposed to electrify 18 000 unelectrified remote villages through renewable energy sources by 2012.

Introduction

The threat posed to sustainability by GHG (greenhouse gas) emissions and deterioration of the natural resource base has caused worldwide concern. The natural resource base has deteriorated considerably due to the rapid growth in population, urbanization, and fossil fuel consumption. The objectives of natural resource conservation and environmental protection need to be integrated with the overall developmental process, as articulated in *Agenda 21* of the United Nations Conference on Environment and Development.

Two important strategies need to be adopted simultaneously for the conservation of the natural resource base. The first strategy pertains to the appropriate pricing of exhaustible or non-renewable resources. Current pricing mechanisms do not reflect the true cost and tend to under-price resources quite significantly. Moving towards true costs or full-cost pricing would encourage fuel efficiency and prevent wastage of energy.

The second strategy is that of developing and promoting appropriate technologies, using renewable natural resources such as biomass, water, wind, and solar energy. Recourse to renewable sources of energy has become imperative with the growing climate change concerns and the dwindling fossil fuel reserves. Although the developed nations have contributed the most to global warming, the contribution of developing countries is also on the rise. In India, electric power generation is one of the largest sources of GHG emissions. The RETs (renewable energy technologies), which are environmentally sustainable, thus have a vast potential for energy generation.

Recognizing the importance of the renewable sources of energy, CASE (Commission for Additional Sources of Energy) was set up in 1981. Subsequently, in 1982, the Department for Non-conventional Energy Sources was created, which was later upgraded to the MNES (Ministry of Non-conventional Energy Sources) in 1992.

IREDA (Indian Renewable Energy Development Agency) was established in March 1987 as a public sector enterprise for the promotion, development, and financing of renewable and energy-efficient technologies. As on 31 March 2001, the cumulative sanctions by IREDA amounted to 46 000 million rupees and the disbursements were 21 000 million rupees (IREDA 2001). Concomitantly, this was accompanied by financial and technical assistance from the World Bank, the UNDP (United Nations Development Programme), the GEF (Global Environment Facility), and the Asian Development Bank.

The MNES has allocated 10% of its budgetary support for the development of the north-eastern states, including Sikkim. It has also included different plans in its various programmes to enhance the role of women, both as beneficiaries and as contributors.

As on 31 December 2000, the contribution of renewables has reached 3000 MW, which is three per cent of the total grid capacity. One of the major contributing factors has been the transfer of small hydro projects with capacity up to 25 MW to the MNES. Potential of RETs, cumulative achievements in 2000/01, and progress made during the Ninth Five-Year Plan are given in Tables 1.102 through 1.105. The applications of various renewable energy technologies are discussed below.

Power generation

Bagasse-based cogeneration

The sugar industry, which generates bagasse as biomass waste, has been targeted for bagasse-based cogeneration as it offers a vast potential and is well organized. It has been estimated that nearly 3500 MW of power can be generated from this industry if the existing 430 sugar mills adopt modern techniques of cogeneration. The total installed capacity as on 31 December 2000 was 273 MW. The potential of each state for bagasse-based cogeneration is given in Table 1.106. Cogeneration projects at 60 ata pressure have been commissioned, and adoption of even higher pressure/better technological configuration (of 80 ata or above) is being promoted. Towards this, additional incentives in the form of interest subsidy linked with higher technological configuration are offered. New cogeneration projects designed at 87 ata pressure and 515 °C are under implementation in Andhra Pradesh and Tamil Nadu.

The major constraints in setting up cogeneration projects are (1) high capital investment; (2) lack of proper policies in respect of wheeling, banking, and buy-back of power generated by the cogenerating industries; and (3) non-remunerative payment against the power exported by the cogenerators (Planning Commission 1997).

The MNES provides subsidies on the equipment cost for projects by using state-of-the-art technology and soft loans for the modernization of projects using relatively established technologies. The state governments provide various fiscal and financial incentives for bagasse-based cogeneration. The Programme Partnership Initiative was launched in 1998 to motivate, assist, and encourage sugar mills to take up cogeneration. Table 1.109 gives the status of biomass power and cogeneration projects. The installed capacity of different states for biomass power projects is given in Table 1.108. The Ninth Plan focused on the promotion of this industry by (1) launching demonstration programmes in cooperative/private sugar industries, (2) providing interest subsidy in the form of soft loans at a low rate of interest, and (3) providing necessary financial and technical support for the preparation of DPRs (detailed project reports).

Biomass gasifiers

Unlike solar and wind energy, chemical energy is stored in biomass (e.g. in coal or oil), which can be released on demand. Hence, storage costs, such as those for a battery, can be reduced drastically. Also, biomass-based power plants are ideal for decentralized applications in rural areas, where it is either costly to extend the grid or the power demand is low.

Agro-processing industries such as cigarette factories, cashew-processing units, and ayurvedic medicine manufacturing units produce large quantities of biomass. The viability of gasifier power plants is strongly linked with the supply mechanisms of biomass. It has been estimated that the area required for biomass-based power generation is 0.03 × 106 kWh/ha a year.

In many states of India, on account of the poor quality of the grid and its reliability, the industries are forced to switch over to their own captive power generation using diesel. Considering the relatively stable and low price of biomass, it makes good sense to couple these gensets with gasifiers. Dual-fuel (gasifier and diesel) operating electric power generators thus offer a great potential for fuel saving and decentralized power generation.

Cumulatively, 35 MW has been installed till December 2000. The distribution of gasifiers in each state is given in Table 1.109.

Solar photovoltaic

Photovoltaic (PV) technology based on solar cells provides one of the most environment-friendly routes for generating electricity. Solar cells are semiconductor devices that convert sunlight into electricity directly without involving any moving parts. Wafers sawn from mono or multi-crystalline ingots of high-grade silicon are the most commonly used semiconductor material for making solar cells today. A thin-film solar cell, where a very thin layer of PV material is deposited on a substrate, is regarded as the technology for the future. Thin-film technology uses less PV material and is considered to be better suited for cost-effective mass production processes.

Some of the characteristic features that make the use of PVs advantageous are as follows.

- Require no fuel, only sunlight (both direct and diffuse sunlight)
- Environmentally clean, make no noise, and emit no gaseous or liquid pollutants
- Modular, can be expanded for growing needs, and can be dismantled for use in other applications
- Robust, reliable, and weather-proof, with a lifetime of over 15 years
- Quick to install, with small gestation period
- Minimal operation and maintenance requirements, which can be met by local trained people also.

Despite these advantages of using PVs, their large-scale deployment is restricted by a few barriers.

- Initial capital costs are high
- Balance of system components is not very reliable
- There is no self-supporting infrastructure for repair and maintenance
- Conventional credit systems for the consumer market are not yet extendable to PV systems
- Market sensitization and consumer awareness is lacking.

PVs can be used both in decentralized and in grid-connected applications. It is suitable for rural remote areas, as well as for specialized applications such as in telecommunications. It is equally suitable for urban domestic or commercial establishments. Globally, PV systems are widely used in the given spheres of activity.

- Rural domestic households for lighting
- Urban commercial establishments for outdoor lighting
- Water pumping for irrigation and drinking water
- Telecommunications in rural telephone exchanges
- Railway signalling
- Battery charging
- Refrigeration
- Offshore oil drilling stations
- PV integrated buildings.

Portable lights, home lighting systems, water pumping systems, and power plants are some of the well-developed and tested systems that cater to these applications.

Global trends and current markets

Although solar cells were extensively used for power generation in space applications, their use

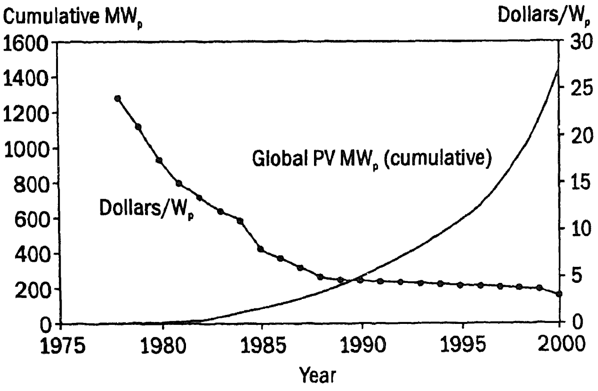


Figure 1 Trends in global PV (photovoltaic) market
Source Kaufman (2000)

in terrestrial applications started only after the oil crisis of the 1970s. Since then, PVs have posted impressive growth on all fronts. Technologically, conversion efficiencies of PV modules have improved from 8%–9% in 1980 to 14% in 2000. During the same period, costs per peak watt have come down from 17–18 dollars to 4–5 dollars. Simultaneously, the global market has grown from less than 5 MW$_p$ annually to 277.9 MW$_p$ annually with the aggregate market in excess of 1.4 GW$_p$ (Figure 1). The market has posted an average growth rate of 15% over the past 15 years. However, the compounded annual growth rate for the past five years has been 29%.

The structure of the market has also changed from early demonstration projects, which focused on the promotion of technology, to a current approach where the emphasis is on product and applications, and consequently on payment for services. PV technology is currently considered to be one of the safest and most reliable alternative power generation technologies, which can be used for a variety of applications in different modes.

In India, annual production volumes are around 11 MW$_p$, with an aggregate system installed capacity of 65 MW$_p$, inclusive of exports equivalent to18 MW$_p$. After the USA, Japan, and the European Union, India is one of the largest markets and manufacturers of PV modules in the world. At present, there are 9 manufacturers of solar cells and 22 of PV modules in the country. There are about 50 companies engaged in the assembly and installation of PV systems.

There are numerous applications of PV technology in the country, such as fixed and portable lighting units, water pumping, small power plants, power for telecommunications, railway signalling, offshore oil platforms, and TV transmission. Several of these applications are commercially viable.

Traditionally, the PV market has been divided into three categories: government, commercial, and individual/household consumer. In the Indian context, this segmentation leads to the following structure.

1 Subsidy market primarily for socially driven schemes and for demonstration of new systems/applications. Products in this category have been lanterns, home lighting systems, water pumping, voltage support system for village grids, etc.
2 Commercial market for specialized applications such as in railways, telecommunications, and exports
3 Consumer-oriented market primarily driven by availability of finance.

In view of the current emphasis and commitment on deploying PV technology through commercially sustainable routes, a more appropriate segmentation of the market has been done.

Minimum rural energy needs

In a developing country such as India, the thrust of the government policies has been providing benefits to the rural population. Electrification is one of the main infrastructure requirements for the overall rural development. An important dimension to rural electrification is the commitment of the government towards socio-economically deprived communities. Support has been given to programmes and projects that address the minimum electricity requirements of the rural poor. Markets for solar lighting systems, mainly portable lanterns and home systems, represent this steady segment, which continues to be benefitted by government support and commitment.

Decentralized energy supply

The second segment is decentralized energy supply for domestic and commercial applications in both rural and urban sectors. This segment is partly supported by government subsidy and partly through soft-term loans that are made available by IREDA, the financing arm of the MNES that funds markets based on RETs.

Since its inception, IREDA has been operating a revolving fund to develop, promote, and finance commercially viable energy-efficient technologies and RETs in the country. With the assistance of grants, borrowings, and lines of credit from the World Bank and other bilateral and multilateral financial institutions, it has been extending soft-term loan assistance to prospective developers in various sectors, including PV. This segment of the market is also supported under projects such as the PVMTI (PV Market Transformation Initiative), a mission by the World Bank and the International Finance Corporation.

Grid-connected power supply

The grid-connected power supply market, although the fastest growing market segment in the developed countries, is at the technology demonstration and validation stage in India. The two applications in this market segment are (1) rooftop systems on public buildings for peak load shaving, and (2) tail-end voltage support for rural grids. Currently, 21 grid-connected power plants with a combined capacity of 1.6 MW_p are commissioned (as shown in Table 1.110); another 0.25 MW_p worth are under installation (Table 1.111). Of the total installed capacity in this segment, about 0.5 MW_p is for voltage support to weaker grids of the rural sections, whereas the rest is installed on public and commercial buildings in urban areas. Typical sizes of the plants are in the range of 25 kW_p to about 0.2 MW_p.

This segment of the market is driven by the demonstration of a new concept in India and validation of the technology. Monitoring the results of a few plants indicate that a typical 100 kW_p grid-connected power plant feeds about 1.4 million kWh annually into the grid.

The BIPV (Building-Integrated PV) market is in its infancy. The lack of indigenous manufacturing of BIPV material and the higher than normal initial costs have restricted the growth of this segment.

Others, including exports

The largest market for PV in India has been for applications such as telecom, power, railway network, oil and gas sector, defence services, and exports. This market is independent of government subsidies and thrives purely on the merits of the technology for providing reliable power to unmanned locations. In the past, DoT (Department of Telecommunications) was one of the largest purchasers of PV systems for providing power to telephone exchanges in rural areas. This market subsided in 1997/98, which affected the demand and, in turn, the industrial production in the country. Exports, however, continue to increase and currently account for 27% of the total production.

Table I presents these segments along with their sub-segments, which are basically the type of products and systems that represent the

Table I Indian photovoltaic market segments

Market segment	*System/product*	*Cumulative* MW_p
Minimum rural energy needs	Lanterns	3.2
	Homelighting systems	5.0
Decentralized energy supply to rural, urban commercial and industrial sector	Power plants	1.1
	Water pumping	4.5
	Streetlights	3.0
Grid-connected power generation and supply	Voltage support for rural grid	
	Roof-top grid-connected systems	1.2
Others and exports	Telecommunications equipment, systems for railways, defence, etc.	47.0

Source MNES (2001)

particular segment. It also gives the value of each sub-segment in terms of cumulative MW_p.

Wind energy systems

Grid-connected windfarms

Wind energy has today re-emerged as the one of the most cost-effective renewable energy sources for grid-quality electricity. India has not only been quick to make a foray into this area, but has also become a top-ranking country in the world in wind power generation. With an installed capacity of over 1267 MW (as of December 2000), India now ranks fifth in the world after Germany, USA, Denmark, and Spain. In the 'State of the World 1998' report by the Worldwatch Institute, India has been projected as the new wind superpower. Wind power installed capacity and generation data are given in Tables 1.112 through 1.115. The estimate of the initial wind power potential at 20 000 MW has now gone up to 45 000 MW, considering the technological advances and availability of modern equipment. The present installed capacity of wind represents a little over one per cent of the total installed power generating capacity in the country. More than 5 billion units of electricity have been generated and fed to state grids from wind power plants.

India has an extensive and advanced ongoing programme of wind energy monitoring and resource assessment. Tables 1.116 and 1.117 give the details of these monitoring stations. Potential windy locations have been identified in the coastal region of southern Tamil Nadu, Kerala, Gujarat, Lakshadweep, Andaman and Nicobar Islands, Orissa, and Maharashtra. Some locations have also been identified in certain parts of Karnataka, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, West Bengal, Uttar Pradesh, and Rajasthan as shown in Map 1. Although the estimated potential is 45 000 MW at a hub height of 50 m, the technical potential is currently estimated at about 9000 MW. As the grid capacity in these potential states increases in the future, the technical potential is also likely to increase. Wind energy potential at 30 m and 50 m hub heights are given in Tables 1.118 and 1.119. The individual wind turbine capacity has also increased from 55 kW in the mid-1980s to 750 kW at present. Megawatt-scale wind turbines are envisaged to enter the Indian market in the near future.

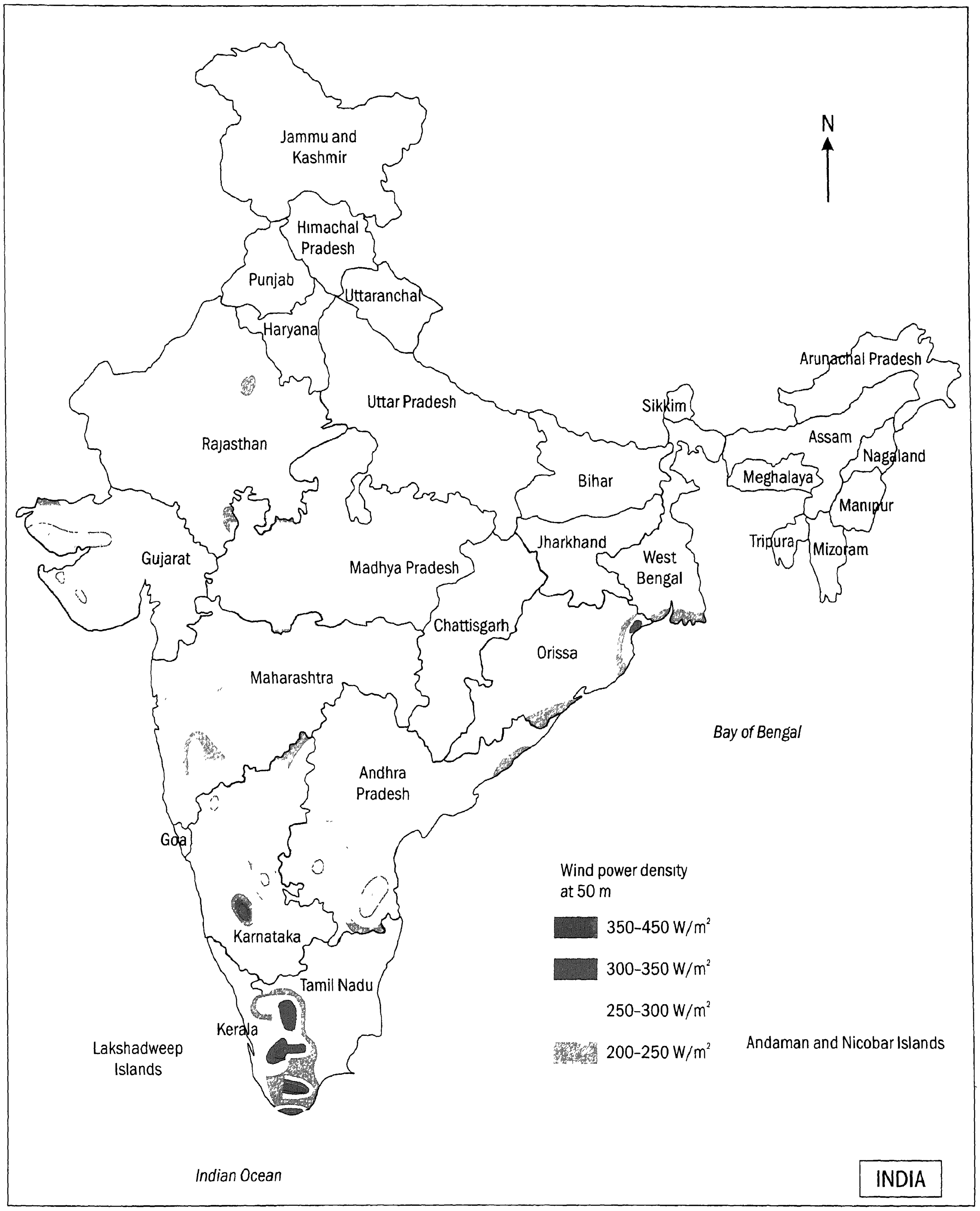
IREDA has been playing a significant role in promoting renewable energy projects in general, and wind power projects in particular. It has attracted bilateral and multilateral finance assistance from the World Bank, the Global Environmental Facility, the Danish Agency for Development Assistance, KfW–The German Development Bank, and the Asian Development Bank. Major national financial institutions such as the Industrial Development Bank of India, the Industrial Credit and Investment Corporation of India, the Indian Finance Corporation of India, the Rural Electrification Corporation, and the Power Finance Corporation have also been financing wind power projects. IREDA's financing norms have been periodically reviewed and reformed in line with the market trends so as to suit the windfarm investor. Another major development has been the entrance of central and state power generating entities such as the National Thermal Power Corporation, the National Hydroelectric Power Corporation, and the State Power Corporation in the wind sector in India. Other leading public sector units are also in the process of diversifying into the wind sector, and a few have already initiated the development of large windfarms.

The performances of wind projects are being closely monitored on a regular basis. The Centre for Wind Energy Technology, set up in Chennai, has already carried out the power curve testing of two wind turbine makes and has initiated other R&D projects to enhance the performance of wind turbines in India.

Wind battery chargers

There are many unelectrified sites in India, which are at such a distance from the main grid lines that it would be uneconomical to extend the grid lines to these sites. If the wind speeds are good enough, wind energy can be used at such locations for providing electricity by installing small wind generators with battery storage (also called wind battery chargers or aerogenerators). The DC power from the batteries can either be used directly to power DC loads (like compact fluorescent lamps) or can be conditioned by an inverter to produce AC to power AC loads.

For more than a decade, the MNES has had a programme to subsidize small aerogenerators to demonstrate and propagate this technology. A statewise list of aerogenerator systems supported by the MNES since 1996/97 is given in Table II.



Map 1 Wind resource in 10 states in India at 50 m above ground

Facing page no 164

Table II Statewise installation of small aerogenerator systems (kW) under the new programme of the MNES since 1996/97 (as on 31 March 2001)

State/Union Territory	*Small aerogenerator systems installed* (kW)					*Cumulative small aerogenerator systems installed*
	1996/97	*1997/98*	*1998/99*	*1999/2000*	*2000/01*	
Andhra Pradesh	4	12	0	0	–	16.0
Assam	6	0	0	0	–	6.0
Kerala	0	0	8	8	–	16.0
Karnataka	0	0	0	25	–	25.0
Rajasthan	0	4	0	0	–	4.0
Tamil Nadu	0	8	0	0	16.5	24.5
Total	10	24	8	33	16.5	91.5

Source MNES (2001)

Wind pumps

In the early 1950s, about 100 Australian 'Yellowtail' machines were imported by the Public Health Department of the Government of India and installed under a project to provide drinking water. During the 1970s and 1980s, several new wind pump models, such as the NAL-MP series, CAZRI, ANILA, POGHIL, and SAMIR, were developed and tested.

In the early 1980s, the 'Apoly 12PU500' was designed and fabricated at the Institute of Engineering Technology, Allahabad, with Dutch assistance. This wind pump has a 12-blade rotor of 5-m diameter directly connected to a piston pump. It was selected by the MNES for large-scale propagation all over India and more than 3000 '12PU500' wind pumps were subsidized by the MNES and installed under the demonstration programmes. A majority of these wind pumps did not perform satisfactorily in the field mainly due to implementation problems such as improper siting and installation, lack of user awareness and training, and poor maintenance. However, the 12PU500 continues to operate successfully in several pockets of Bihar and Gujarat where site conditions are suited to the wind pump (wind speeds are low and the water table is high), and the users have learned to take care of routine maintenance.

Since 1993, the MNES has also been supporting 3-m diameter geared-type deep-well wind pumps under its demonstration programme. This is a first-generation wind pump that has a proven performance record for unattended operation in Argentina, Australia, Canada, USA, etc.

Another wind pump supported by the MNES under their subsidy schemes is the 'AV-55' developed by the Centre for Scientific Research, Auroville (5.5-m diameter, 18-blade, direct-drive). The subsidy provided by the MNES on these wind pumps during 1999/2000 is given in Table III. It is likely that these subsidy levels will be maintained during 2000/01.

A statewise list of windpumps supported by the MNES since 1994/95 is given in Table IV.

Table III Subsidy on wind pumps

Wind pump	*Rotor diameter* (m)	*Type of drive*	*Approximate total cost*[a] (Rs)	*MNES subsidy* (Rs)
Modified 12PU500	5.0	Direct	40 000–50 000	20 000
3-m, Geared type	3.0	Geared	60 000–80 000	30 000
AV-55	5.5	Direct	120 000–140 000	45 000

[a] Total cost depends on depth of the water table and tower height.

Table IV Statewise installation of water pumping windmills under the programme taken up by the MNES from 1994/95 (as on 31 March 2001)

State / Union Territory	*Windmills installed*							*Cumulative windmills installed*
	1994/95	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*	
Andhra Pradesh	0	0	0	0	1	1	0	2
Assam	0	0	3	0	0	0	0	3
Andaman and Nicobar Islands	0	0	0	0	0	2	0	2
Bihar	0	30	0	12	0	0	0	42
Gujarat	3	32	36	57	6	86	57	277
Karnataka	0	3	0	11	0	6	0	20
Kerala	10	14	20	11	0	12	12	79
Maharashtra	3	1	0	7	0	7	0	18
Rajasthan	32	8	32	100	50	0	0	222
Tamil Nadu	8	2	7	7	5	12	8	49
Total	56	90	98	205	62	126	77	714

Source MNES (2001)

Hybrid systems

Wind–solar photovoltaic–diesel hybrids

Renewable energy power supply systems such as SPV (solar photovoltaics) and wind generators depend on natural resources (solar radiation and wind speed), which exhibit both diurnal and seasonal variations. When such systems are connected to a large grid, the diversity of power plants feeding power into the grid (coal–thermal, large hydel, gas turbine, nuclear, etc.) are able to maintain continuity of power supply when solar radiation or wind speeds are low or zero. For stand-alone systems operating in locations where there is no grid supply, a storage system (usually lead–acid batteries) is used to provide power during periods of low resource availability. To ensure reliability of the power supply throughout the year, the system has to be large (and expensive) since it has to be designed for that period of the year when solar radiation or wind speeds are the lowest. Also, the battery storage has to be sized to cater to a number of days of autonomy (i.e. cloudy days for solar systems or windless days for wind power systems).

However, there are many locations where the wind and solar resources are complementary, i.e. the solar radiation is low during periods of high wind speeds and vice versa. For example, in many parts of peninsular India, during the monsoon months, solar radiation is low and wind speeds are high, whereas during the rest of the year the radiation is high and the wind speeds are low. For such sites, the required reliability in power supply can be met in a more economical way by using a combination of SPVs and wind generators to charge the same battery bank. To improve the reliability of such 'wind–SPV hybrid systems' and to keep costs down, a DG set can be included to charge the batteries during short periods of the year when the sum of the wind and solar resources is inadequate. Dual-mode inverters are now available, can also act as battery chargers for charging the batteries from the DG set; in addition, they can also be operated simultaneously with the DG set to meet a higher peak load than either of them can alone.

During 1998/99, the MNES supported a 4-kW aerogenerator system in Kerala, which is being used with a 1 kW_p SPV array in a hybrid configuration. During 1999/2000, the MNES supported four hybrid systems in Karnataka and Maharashtra. The wind–SPV hybrid in Karnataka consists of a 2.5-kW aerogenerator with a 5.25-kW_p SPV array, whereas all three hybrids in Maharashtra consist of 3-kW aerogenerators coupled to 2-kW_p SPV arrays. The cumulative capacity installation of hybrid systems till 31 December 2000 is 76.5 kW.

Small hydropower

The total potential for SHP (small hydropower) (up to 25 MW) in India has been estimated to be about 15 000 MW. SHP generation is an important energy supply option for several reasons; two of the most important are given below.

- India is a large country and there are several remote places where grid extension for power availability is technically and economically unviable. SHP provides an excellent alternative for local power generation and consumption, wherever it can be installed.
- Unlike large hydropower stations, SHP does not have negative environmental and social impacts such as submergence of land, and rehabilitation and resettlement of people.

A total of 4096 sites, with an aggregate capacity of 10 071 MW, have already been identified in various states, as shown in Table 1.120. India has 387 SHP up to 25 MW station capacity, with an aggregate capacity of over 1341 MW. These projects are spread throughout the country in hilly regions and on canal drops. Over 170 projects with an aggregate capacity of 498 MW are under construction. Besides, the MNES is implementing a UNDP/GEF technical assistance project entitled 'Optimising development of small hydro resources in Himalayan and sub-Himalayan regions'. The work is being carried out in Arunachal Pradesh, Assam, Bihar, Himachal Pradesh, Jammu and Kashmir, Manipur, Mizoram, Nagaland, Sikkim, Meghalaya, Tripura, Uttar Pradesh, and West Bengal. The project envisages the preparation of zonal plans and a master plan for these regions, besides setting up 20 demonstration projects based on different commercially viable and environmentally sound technologies, and upgrading 10 existing water mills into multipurpose units. The project ends in December 2001.

The zonal plan for all the 13 states has been prepared and 2162 potential sites aggregating 3827 MW have been identified. These sites have been categorized into different ranges of capacity and head. Two projects – Juthed (100 kW) and Kothi (100 kW) in Himachal Pradesh – have been completed this year and 17 projects are under execution. A hundred water mills based on the modified designs have been installed in Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, and Uttar Pradesh.

Energy from urban and industrial wastes

Waste management technologies have now assumed relevance and importance in India. As shown in Table 1.102, nearly 1000 MW can be generated from urban and municipal wastes and about 700 MW from industrial wastes. Different categories of wastes and their estimated quantities are given in Table 1.121. Under the National Programme on Energy Recovery from Urban and Industrial Wastes, work has commenced on projects with an aggregate capacity of about 11 MW_e during 2000/01. Details are given in Tables 1.122 and 1.123. Apart from this, there is a major thrust on R&D. To speed up the various programmes, the National Bioenergy Board has been set up to evolve policy guidance and direction. As regards the ongoing UNDP/GEF-assisted project 'Development of high rate biomethanation processes' (started in September 1994), the achievements during 2000/01 are as follows.

- Preparation of a National Master Plan for the development of waste-to-energy sector in the country has begun with the organization of a national workshop wherein representatives from various organizations, such as central and state government departments, technology providers, experts, consultants, financial institutions, multi-national agencies, etc. participated.
- Turnkey execution of the following demonstration sub-projects has been undertaken.
    - 0.3-MW-power project utilizing 60 tonnes per day slaughterhouse solid wastes at M/s Al Kabeer, Medak, Andhra Pradesh.
    - 300-m^3 biogas per day biomethanation plant treating solid wastes of leather industry at Tata International Ltd, Dewas, Madhya Pradesh.

A number of state governments and state agencies have initiated projects for energy recovery from rural and industrial wastes. Projects based on conversion technologies, namely biomethanation, pelletization, gasification, pyrolysis, incineration, and sanitary landfills, are being developed with the support of the MNES. However, there is a need to launch more demonstration projects. Also, private sector participation can be encouraged by providing adequate financial and fiscal incentives as well as by defining necessary legislation, wherever required, for waste disposal, etc.

Thermal applications

Biogas plants

The National Project on Biogas Development was started in 1981/82 for the promotion of family-type biogas plants. The project aims at providing a clean and inexpensive energy source, producing enriched manure, improving sanitation, and elevating the status of women in rural areas. Against a potential of 12 million biogas plants, 3 million family-type biogas plants were installed till December 2000. Table 1.124 gives the details of family-type biogas plants in each state.

Biomass gasifiers for thermal applications

Gasification technology in India has so far been solely an indigenous effort, in terms of technology development, upgradation, application package development, dissemination, etc. The National Biomass Gasifier Programme focuses on development and commercialization of appropriate conversion and utilization technologies such as biomass briquetting and gasification to meet various energy requirements in the domestic and industrial sectors. The techno-economic feasibility of utilizing biomass gasifiers for a variety of thermal applications has been well established now. Table V depicts biomass usage in industry in the South and South-East Asian regions.

A potentially large industrial sector is the calcium carbonate industry where each plant uses multiple units of coal gasifiers of 750-kW_e capacity. Due to an increase in coal prices, a biomass gasifier can be the ideal energy supplier. There are about 100 such plants in India. Another area is the *khandsari* industry. There are about 2000 such units in India requiring thermal energy in the range of 200 kW. Some other potential areas are mini cement plants (around 400), production of carbon dioxide, magnesium chloride, tea, etc. The lower capacity gasifiers are used in small-scale industries such as silk reeling, textile dyeing, drying, and in community cooking. Experience so far has shown that biomass gasifiers for thermal applications have inherently low payback periods. Moreover, the use of gasifiers offers substantial reductions in fuel consumption and harmful emissions.

Biomass gasifier systems have great relevance in the context of global GHG emissions, as well as low or even negative abatement costs. Although combusting wood emits carbon dioxide into the atmosphere, the re-growth of wood captures carbon dioxide from the atmosphere again. Thus, there is no net emission of carbon into the environment.

Improved cookstoves

The National Programme on Improved Chulhas was launched in 1984/85 with the objectives of fuel conservation, reduction of smoke, conservation of forests and the environment, providing employment, and elevating the status of women and children in rural areas. Improved *chulhas*

Table V Biomass energy in industry

			Woodfuel		*All biomass*	
Country	*Year*	*Total industrial energy use*[a]	*Energy*[a]	*Share*[b]	*Energy*[a]	*Share*[b]
Bangladesh	1994	178 000	28 500	15.9	114 900	64.2
Cambodia	1995	533	383	71.9	383	71.9
India	1996	4 656 003	375 000	8.1	1 094 878	23.5
Malaysia	1993	1 297	293	22.6	293	22.6
Nepal	1997	15 951	3 684	23.1	3 935	24.7
Pakistan	1994	422 280	N/A	N/A	92 318	21.9
Sri Lanka	1996	51 163	21 773	42.6	26 826	52.4
Thailand	1997	700 367	42 789	6.1	194 853	27.8
The Philippines	1995	279 211	38 220	13.7	77 533	27.8
Vietnam	1995	219 427	43 500	19.8	87 250	39.8

[a] Energy measured in Terra Joules; [b] Percentage of total industrial energy consumption

Source *Wood Energy News* June 1999 **14**(1) have a thermal efficiency of 20%–35% as compared to the traditional *chulhas*, which have an efficiency of 10%. In addition, improved *chulhas* are estimated to save about 11 million tonnes of fuelwood equivalent every year. The cumulative achievement is over 33 million improved *chulhas* up to 31 December 2000. The details of installations in each state are given in Table 1.125. However, an evaluation study by the NCAER (National Council for Applied Economic Research) for 1992–95 revealed that (1) nearly one-fourth of the *chulhas* installed stopped functioning within a year of their installation, (2) the maintenance of *chulhas* by beneficiaries was poor, and (3) the number of self-employed workers and their competence was short of the requirements. The pattern of subsidies for the promotion of improved *chulhas* has been further rationalized to encourage market support.

Solar thermal technologies

The following section discusses the utilization of solar thermal energy for various end-uses.

Solar water heating systems

In India, solar thermal systems are used mainly for domestic and industrial applications. In the industrial sector, solar thermal energy is utilized for preheating boiler feed water and also for supplying direct process heat. The resultant savings are mainly in terms of boiler fuel. Moreover, solar water heating systems are also used to meet hot water requirements in hotels, hospitals, and hostels. In the domestic sector, the replacement of electric geysers by solar water heating systems results in saving of electrical energy. Small capacity-systems (up to 2000 litres per day) work on natural circulation or the thermosyphon principle. However, for larger-capacity systems, pumps with necessary controls are required for circulation of water, such systems are designated as forced flow systems. According to a conservative estimate, the potential for the deployment of solar water heaters is around 140 million m^2 of collector area, of which 550 000 m^2 has so far been installed in India till 31 December 2000. The trend of installation of solar water heating systems over the years is shown in Figure 2. Solar water heaters can be effectively used in demand-side management, as approximately 1000 solar domestic water heaters (2000 m^2 of collector area) can contribute to a peak load shaving of 1 MW.

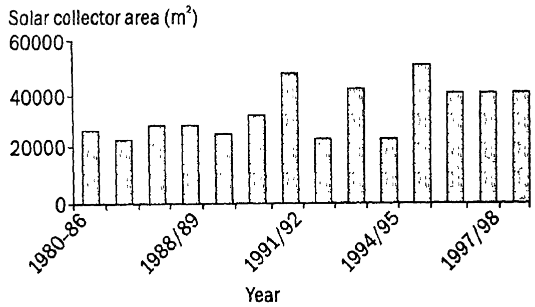


Figure 2 Solar water heating systems
Source MNES (2001)

Considering the vast potential and resource availability, the Government of India, through the MNES, provided various interventions in terms of subsidy and other fiscal benefits to promote solar water heating systems. These subsidies were abolished in July 1993 when the technology attained a certain level of commercialization. Instead, provisions were made to avail soft loans through IREDA and some other designated banks.

Solar energy for industrial applications

A major portion of thermal energy requirements in the Indian industrial sector lies in the temperature range of 100 °C–250 °C, which corresponds to the medium-temperature range of solar thermal systems. This is supplied either as high-temperature pressurized water or as low-pressure steam. These medium-temperature requirements are met primarily by combustion of fossil fuels such as coal, lignite, and furnace oil. There are 22 major industries where boilers supply process heat in the form of either steam or hot air up to a temperature of 150 °C. These industries include dairy, food processing, textiles, hotels, edible oil, chemical, marine chemicals, bulk drug, breweries, and distilleries.

Solar thermal systems can be employed to meet this demand in a complementary manner. It is estimated that about 60% of the thermal energy consumed in the industry is used to process end-products. Even if only 10% of this requirement is met through solar thermal systems it will lead to savings of about 292 400 kilolitres of furnace oil a year and a reduction in the resultant carbon dioxide (Dr Rao Associates 1991).

Solar cooking

In the household sector in India, the bulk of energy is spent on cooking, though in the urban households, there is a gradual shift from fuelwood to LPG (liquefied petroleum gas) for cooking. Therefore, cooking with solar energy appears to be a viable option in the domestic sector. At the micro level, solar cookers facilitate financial savings for the consumer; at the macro level, they help in the conservation of LPG and fuelwood. Moreover, cooking through solar cookers also helps in abatement of the greenhouse effect. Of the many types of solar cookers such as concentrating (dish) type solar cookers, indirect heating type solar cookers, with or without heat storage, and hybrid type solar cookers, the box-type solar cookers have reached the commercialization stage. Nearly 497 000 cookers have been sold till 31 December 2001. In April 1994, the subsidy provided by the MNES on solar cookers was replaced by financial support for promotional activities such as publicity, cooking demonstrations and competitions, and training. Soft loans are presently available for the purchase of solar cookers through some designated nationalized banks.

Besides more popular box-type cookers, there are 'concentrating cookers', e.g. parabolic dish type cookers. A parabolic dish solar cooker has a concentrator that concentrates the solar radiation on to a focal point. The cooking pot is placed at the focal point. The advantage of this type of concentrator system is that it can reach higher temperatures; besides, cooking this way is much faster compared with that by other box-type cookers. On the other hand, the need for frequent tracking forces the user to work in the sunshine under particularly strenuous conditions of heat and glare. In addition to preparing cooked meals, the concentrating-type solar cooker is suitable for sterilizing water, baking, and frying.

The Scheffler cooker is the latest community solar cooker design in India. It comprises a parabolic dish that reflects solar light into the kitchen and then on to a secondary reflector located below a specially designed cooker. The cooker's temperature can be regulated as easily as in conventional cooking. Moreover, with only a single setting in the morning, a special automatic tracking feature rotates the parabolic dish to follow the sun and maximize reflection throughout the day. Unlike other parabolic dishes, it is flexible, with a curvature that can be seasonally adjusted. This cooker can cook 100 meals at a time.

One of the world's biggest solar cookers is operating at Mount Abu in India. Heat from Scheffler concentrators is reflected on to a heat exchanger, and the resulting steam is used for a wide range of purposes, including the preparation of over 10 000 meals daily. The system has been designed to generate about 4000 kg of steam a day. Almost all the components of the system are indigenous, except the reflecting mirrors which have been imported from Germany. The system is of hybrid nature, backed with an oil-fired boiler to make it reliable under all weather conditions.

Solar thermal power generation

Of the various energy uses or sources contributing to the global greenhouse effect, energy-related carbon dioxide emissions are the largest single source, with power plants contributing about 11% of the carbon dioxide emissions. In this scenario, to mitigate the greenhouse effect, the introduction of more costly but cleaner energy technologies such as solar thermal power generation is imperative.

For electricity generation through the solar thermal route, the following technologies are feasible: (1) parabolic dish, (2) parabolic trough, (3) central receiver, (4) solar pond, and (5) solar chimney. Of these, the line-focusing parabolic trough technology is commercially available. The 354-MW capacity plants in California, based on the LUZ parabolic trough technology, continue to operate, although no further development has taken place there on account of financial problems. Despite this setback, the plants mark a major step forward in the commercialization of solar thermal power by bringing down the power cost from $0.24/kWh in 1984 to $0.08/kWh in 1989 through various technological and operational innovations. The Solar PACES programme indicates that the levelled electricity cost of solar thermal power plants can be reduced with increased size to around $0.13/kWh for state-of-the-art 100-MW technologies and to a range of $0.08–0.11/kWh for future 100-MW commercial developments.

The EC (European Community) is focusing on a strategy to develop these technologies and reduce costs so that market forces alone support the industry by 2010. The world market is predicted to be 5.1 GW a year during 2010–15, including an 800-MW a year potential for India.

Apart from grid-connected centralized power plants, solar thermal power generation plants can also operate in the stand-alone mode in decentralized applications such as rural electrification and in remote locations like islands. It is estimated that if the cost of extending the grid to the remote location is also taken into account, solar thermal power from a parabolic dish is more viable than grid power. In the centralized mode, parabolic trough–natural gas hybrid systems with 25% solar share appear to be most competitive.

The 140-MW integrated power plant comprises solar and conventional fuel-based components. The capacity of the solar-alone plant is 35 MW and the balance of 105 MW is proposed to be based on naphtha. On examining the available data for different proposed sites, Jodhpur was found to be the most appropriate site for such a venture. Using a baseline case of a coal-fired 140-MW power station, the marginal cost of the solar plant has been estimated at 83 million dollars (about $2400/kW). The RSPCL (Rajasthan State Power Corporation Ltd) will implement the project. The approximate total cost is 280 million dollars, to be financed by a combination of a GEF grant, loans (from commercial organizations and bilateral agencies), and equity. The GEF and KfW funding are in place. Once installed, the plant will operate autonomously as an independent power producer and will sell power to the grid based on a power purchase agreement with the RSPCL.

Solar ponds

Salt-gradient solar ponds (low-cost solar collectors with integral storage) are both appropriate and relevant in the Indian context. Solar pond research in India was initiated at the Central Salt and Marine Chemicals Research Institute, Bhavnagar, in 1971—shortly after the completion of the initial phase of work in Israel. A 1210-m^2 bittern-based solar pond was constructed and operated. Solar pond work was resumed in 1980 with the construction of a 1600-m^2 pond. A 100-m^2 pond at the Field Research Unit of TERI, Pondicherry, and a 240-m^2 pond at the IISc (Indian Institute of Science), Bangalore, were constructed and operated successfully around the same time. These three ponds successfully demonstrated solar pond technology in India, but they were not connected to any end use. Moreover, the construction and operation of a large-sized solar pond (the largest solar pond so far is of 1600 m^2) was not tried out. The 6000-m^2 solar pond at the Kachchh Dairy, Bhuj, was conceived as an R&D project to demonstrate the feasibility of using a salt-gradient solar pond to deliver industrial process heat. The construction of this pond was started in 1987 as a collaborative effort of the Gujarat Energy Development Agency, the Gujarat Dairy Development Corporation Ltd, and TERI. The Bhuj solar pond is a major technology development effort undertaken jointly by a state energy promotion agency, a user industry, and a research institution. The Bhuj solar pond started supplying hot water to the dairy in September 1993, saving about 935 MT of lignite a year, at full capacity utilization of the solar pond. Around the same time, a project of a similar scale was sanctioned to the Electricity Department of Pondicherry, primarily for power generation. As an offshoot of the IISc pond work, two more ponds were constructed in Masur and Hubli in Karnataka to supply hot water for bathing. A small solar pond had also been constructed in Ranchi.

The economic viability of a salinity-gradient solar pond is governed by factors such as its size, proximity to sources of inexpensive salt/bittern and water, and land availability. The following niche areas have been identified after careful matching of these requirements with the deliverables: (1) process heating, (2) water desalination, (3) refrigeration, (4) production of magnesium chloride, (5) bromine recovery from the bittern, and (6) enhancement of the salt yield in salt farms.

Solar air-heating systems and solar architecture

Apart from heating and cooking, solar energy is also being used for drying farm produce, which minimizes the post-harvest loss caused by open sun drying. The partial energy delivery unit, with 4500 m^2 of collector area, has been installed in the southern parts of India to pre-heat the air for drying tea, spices, etc. Solar air heaters are also being used for space heating in some buildings in Himachal Pradesh.

The benefit of solar energy is also being taken in the form of solar passive architecture while designing energy-efficient buildings. This minimizes the use of conventional fuels and electricity. A programme comprising training and education, demonstration, and publicity has been implemented by the MNES to promote solar-based building designs. Under the Solar Buildings Programme, a number of solar buildings have been constructed in Himachal Pradesh, where the main requirement is that of space heating. Such buildings include office buildings of the state nodal agencies in Delhi, Himachal Pradesh, Madhya Pradesh, Punjab, and West Bengal.

TERI has developed a solar passive system for thermal comfort conditioning of buildings in composite climates. It was observed that an almost constant temperature of 28 °C during summer was maintained inside the passive solar room when ambient temperature went up to 42 °C. Similarly, in winters, the solar passive room remained at around 16 °C throughout the 24 hours when the ambient temperatures dropped to nearly 1 °C at night. TERI has also constructed the first sustainable building complex in Gurgaon, Haryana. RETREAT (Resource Efficient TERI Retreat for Environment Awareness and Training) is a unique example of a sustainable habitat design in the country. The building uses several innovative technologies to reduce its energy demand to one-third that of a conventional building of the same size and function. It is fully powered by renewable sources of energy and is not connected to the Haryana state electricity grid. The complex has a waste water recycling plant to recycle and reuse waste water.

New technologies

Chemical sources of energy

Currently, four types of fuel-cell technologies, namely phosphoric acid, polymer electrolyte, solid oxide, and molten carbonate fuel cells, are receiving attention for commercialization. However, the high initial costs and the unproven long-term performance are the main deterrents for their widespread application to generate electricity and heat.

Ocean energy

Ocean thermal energy, tidal energy, ocean winds, and wave energy are the various forms of ocean energy that are being explored. However, at the present level of technology, only tidal energy can be harnessed. It has been estimated that the total potential of ocean energy is approximately 50 000 MW. A few potential sites have been identified for tidal power development at the Gulf of Kachchh and the Gulf of Khambhat in Gujarat and in the Sunderbans Delta in West Bengal.

Geothermal energy

Geothermal energy, which is derived from high-temperature geothermal fluids, can be utilized for power generation and thermal applications such as greenhouse cultivation, space heating, power generation, and cooking. So far, projects on an experimental basis for the cultivation of mushrooms and poultry farming have been implemented in Ladakh. Of the 300 geothermal spring locations in the country, only those in Jammu and Kashmir and Madhya Pradesh can be used for power generation whereas the other fields can be used for non-electrical applications. Proper utilization of geothermal energy requires adequate infrastructure and training.

Alternative fuels for surface transport

Hydrogen is a clean energy carrier with a high heat content, which can be produced by electrolysis of water using solar energy. Hydrogen can be used in the transport sector to substitute petroleum products.

The MNES is promoting the substitution of petrol-driven vehicles by BOVs (battery-operated vehicles) and diesel-run vehicles by alcohols such as ethanol and methanol. To facilitate the implementation of BOVs and alcohol-operated vehicles, the MNES offers subsidies. However, the use of BOVs has been constrained by inadequate infrastructure support for charging/replacement of batteries, poor performance, high maintenance cost, failure of components, etc. Thus, initiatives have been taken by the ministry to develop batteries with high energy and power density, longer life cycle, and maintenance-free, and are less polluting. Efforts are being made to develop and commercialize advanced lead–acid, nickel–metal hydride, and nickel–iron and lithium batteries.

Renewable-energy-based water desalination systems

Water is increasingly becoming a scarce resource in most parts of the world, including India. The water supply position is disturbing, especially in many villages where women have to trek long distances to fetch potable water. The responsibility of water collection and provision has traditionally been with women. Since women are the providers of water, depleting water resources implies greater burden and drudgery for them, each dried-up source implies longer walks and more work. As per one estimate the amount of time women spend in carrying water varies across regions and can be as high as 4 hours per day. The semi-arid and arid regions of south-central and north-western India forming parts of Tamil Nadu, Andhra Pradesh, Gujarat and Rajasthan constitute the priority areas for supply of potable water from brackish water sources. Nearly 79 000 habitations reportedly still lack any source of safe water. Out of 575 000 villages in the country, about 162 000 villages have been identified as having problems of brackishness, scarcity, and contamination of drinking water.

One of the main reasons for freshwater scarcity is the over-exploitation of groundwater. The over-pumping, especially along the coastal regions, has led to severe salinity ingress, making the water brackish and unfit for human consumption. Besides, in many areas, fresh and saline aquifers are often in close proximity and pumping out the freshwater (without corresponding recharging) has caused inflow of saline water into freshwater systems. The combination of all these factors has created an acute drinking water problem.

Under the circumstances, desalination of brackish/sea water could solve this critical problem. Since India is blessed with a variety of renewable energy resources, renewables-based water desalination can offer a sustainable option. As most of these habitations/villages are in remote areas, desalination plants working only on conventional fuels may not be either economical or reliable. Desalination plants powered by renewable energy are specifically suited to provide drinking water to rural and interior areas where neither potable water nor electricity is available.

Desalination, or desalting, is a water treatment process that removes salts from water. Desalination requires significant quantities of energy to achieve separation. Therefore, energy cost constitutes the single major component of the total cost of desalinated water, estimated to be as high as 50%–60%. Furthermore, potable drinking water is required mostly in areas that lack all kinds of resources, including conventional energy. Thus, it makes greater sense to have systems that are designed on the basis of area-specific needs as well as input water quality, and which can run on locally available renewable energy resources.

Essentially, in the case of renewable-energy-based desalination systems, instead of conventional fuel or electricity, renewable energy sources such as solar or wind energy become the source of energy. Thus, these systems can be classified as follows.

- Solar thermal technologies
- SPV technologies
- Wind energy technologies.

Solar stills

The use of direct solar energy for desalting saline water has been investigated and used for some time. These devices are popularly known as solar stills. During World War II, considerable work went into making small solar stills for use on life rafts. This work continued after the war, with a variety of devices being made and tested.

These devices generally imitate a part of the natural hydrologic cycle in that the saline water is heated by the sun's rays so that water vapour is produced. The water vapour is then condensed on a cool surface, and the condensate is collected as product water. An example of this type of process is the greenhouse solar still, in which the saline water is heated in a basin on the floor and the water vapour condenses on the sloping glass roof that covers the basin. The solar still can desalt saline water and seawater by distillation using solar energy. This technique not only desalts saline water but also removes toxic ions and bacteriological contamination, which are injurious to health. Thus, solar stills are ideal to provide safe drinking water to isolated communities of small villages, islands, lighthouses, and salt works. In solar stills, the only moving part is the pump, which pumps saline water from the well. These units can be constructed in modular form and provide a viable option for providing potable water for a single house or a group of families.

Solar pond desalination systems

Solar ponds located in arid regions where abundant brackish water is available may be excellent sources of energy for water desalination. This is because the solar pond can provide the thermal energy required for the process cheaply and the pond can also be a repository for the concentrated waste brine, disposal of which is often difficult, particularly with anti-pollution laws becoming stricter every day.

A solar pond coupled to an energy-efficient desalination system offers the highest potential for producing potable water on a large scale at competitive costs, compared to the existing fossil-fuel-powered desalination systems, for the locations where salt/bittern is available in abundance. Concentrated waste brine left after desalination can be recycled into the solar pond.

When concentrated brine is substantial, it can be used to breed additional solar ponds, thereby solving the problem of waste disposal and providing more energy.

The thermal energy extracted from the solar pond is utilized to heat up the raw brackish water. The heated water is then introduced in either multi-stage flash evaporation or multi-effect distillation units, where the usual process takes place. The only difference is that since the maximum brine temperature is around 80 °C, to facilitate the evaporation a vacuum has to be created. A small amount of electrical power is required to meet the pumping needs.

Solar PV-electrodialysis

In such systems, DC electricity supplied by SPV panels is used for ED (electrodialysis) of brackish water. In most of PV-ED systems, a battery backup with a charge-level controller is usually incorporated to operate the systems during cloudy periods and also to extend operational period beyond normal, daytime hours. Another option is to directly couple the ED unit with the PV panels. PV–ED is suitable for a small community where grid power is not available.

Solar-powered reverse osmosis

SPV panels can also be used to provide electrical power for driving pumps in a reverse osmosis system. The systems can be designed to operate with or without storage batteries. However, in case there is no battery, maintaining steady-state conditions becomes fairly difficult.

Solar membrane distillation

This solar membrane distillation system uses heat and electricity generated solely by solar energy to operate the membrane distillation process. Thermal energy to heat the water is provided by solar collectors, and the pumps are powered by PV panels. A variable voltage, variable frequency inverter connected to the PV system automatically starts up the desalination system according to the amount of solar radiation available and runs the pumps by controlling the output of the PV system. Freshwater production varies with the solar radiation.

Wind-powered reverse osmosis

Considering the intermittent availability of wind energy, the possible alternatives are: (1) direct coupling of reverse osmosis with windmill, (2) battery storage and DC operation, and (3) AC operation.

In the directly coupled reverse osmosis system, standard windmill is used to pump brackish water into pressure vessels that could be pumped up to the operating pressure of the system. In strong winds, the system operates in a steady state with the pressure vessel acting only as a surge suppresser to even out the flow. During lower wind speeds, the pressure vessel gradually builds up the pressure, thereby operating in cycles throughout the day.

Alternatively, a wind turbine is used to generate electrical power, which is then used to drive the pumps of the reverse osmosis system. Here it can be a wind battery charger, which produces DC current and charges the battery. This stored power can be used to operate the pumps. In the AC mode, a wind electric generator can be used, which directly generates AC power. Alternatively, a battery with an inverter can be used.

Wind-powered electrodialysis

In a wind-powered electrodialysis system, a wind battery charger produces DC current and charges the battery. This stored power can then be used for electrodialysis of brackish water.

Barriers in the propagation of renewables

India's current policy environment has been successful in creating one of the largest and most diverse renewable energy programmes in the world, with a broad technological base and large human capacity. With these strengths, the RETs are now poised to move into the energy mainstream. However, despite these accomplishments, the following issues are yet to be addressed.

- The markets and market-support infrastructure for renewable energy products are still underdeveloped.
- Product development is poor, and continues to be largely supply-driven rather than being responsive to user needs.
- The linkage between the market requirements (for product development, deployment and technological upgradation) and the R&D process is weak.
- There is limited access to renewable-energy-based products and credit.
- Provision of high-quality energy services from renewables (through hybrids or dedicated energy-service companies) is completely lacking.

- The incorporation of renewable electricity into the state grids is constrained by the lack of consistent policies, and current tariffs discourage both stand-alone and local grid-based renewable energy systems.

Future outlook

India is well endowed with substantial renewable energy sources. However, the exploitable potential depends upon the availability of resources, the status of technology, and the end-use patterns.

The application of RETs is largely influenced by the degree of R&D, development of appropriate products (based on consumer needs), and their commercialization. Enhanced international cooperative activities aimed at sharing technological expertise, promoting scientific research, and mobilizing financial resources can also contribute immensely to the development of RETs. Limited resources are a serious constraint and, therefore, the MNES has adopted a strategy whereby projects jointly implemented by the industry/institutions are given a priority.

Widespread information dissemination and awareness campaigns need to be launched to apprise people of the benefits of RETs and their advantages over other technologies. RETs have relied heavily on central subsidies provided either directly through IREDA or through centrally-sponsored schemes. The need, therefore, is to shift from capital subsidies to interest subsidies and gradually move towards private entrepreneurship and community participation by phasing out subsidies. Suitable legislation and policy, along with a necessary regulatory mechanism, have to be evolved for promoting these technologies.

References

Dr Rao Associates. 1991
Technology development for solar thermal process heat in medium temperature range for industrial application
Report submitted to Progressive Programmes for Acceleration of Commercial Energy Research under ICICI
Hyderabad: Dr Rao Associates

IREDA. 2001
http://ireda.nic.in/vsireda/milestones.htm
[accessed on 30 June 2001]

Kaufman S. 2000
Rural electrification with solar energy as a climate protection strategy
Washington, DC: Renewable Energy Policy Project

MNES. 2001
http://mnes.nic.in
[accessed on 17 October 2001]

Planning Commission. 1997
Ninth Five-Year Plan (1997–2002). Volume II
New Delhi: Planning Commission, Government of India.

Table 1.102 Renewable energy potential and achievements in India

Sources/technologies	*Units*	*Approximate potential*	*Achievements (till December 2000)*
Wind power	MW	45 000	1267
Small hydropower (up to 25 MW)	MW	15 000	1341
Biomass power	MW	19 500	308
Biomass gasifiers	MW	16 000	35
Biomass cogeneration	MW	3 500	273
Urban and industrial waste-based power	MW	1 700	15.20
Solar photovoltaics	MW/km^2	20	47
Solar water heating	million m^2 collector area	140	0.55
Biogas plants	million	12	3.10
Improved biomass *chulhas* (cookstoves)	million	120	33.00

Source
MNES. 2001. ***Renewable Energy in India: business opportunities.*** New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.103 Capacity addition of various sources of non-conventional energy during 2000

Source	*Capacity* (MW)
Wind power	187.0
Biomass power	51.0
Biomass gasifier	1.0
Solar power	5.0
Waste-to-energy projects	11.0
Small hydropower	72.3

Source
MNES. 2001. ***Renewable Energy in India: business opportunities.*** New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.104 Global position (MW) of Indian renewable energy programmes

Sources/technologies	*Cumulative achievements*	*India's position in the world*
Wind power	1267.0	Fifth
Small hydropower (up to 25 MW)	1341.0	Tenth
Biomass-based power	273.0	Fourth
Biomass gasifiers	35.0	First
Solar photovoltaics	47.0	Fourth
Energy from urban and industrial wastes	15.2	–

Source
MNES. 2001. ***Renewable Energy in India: business opportunities.*** New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.105 Progress in programmes during the Ninth Plan

Type	*Ninth Plan target*	*1997-99*
Wind power (MW)	1200.00	123.00
Small hydro (MW)	130.00	39.19
Biomass power (MW)	314.00	85.00
Urban and industrial wastes (MW)	50.00	3.00
Biogas plants (million)	1.26	0.32
Improved *chulhas* (million)	19.60	4.61

Source

Planning Commission. 2001. http://planningcommission.nic.in/midf.htm

Table 1.106 Potential for bagasse-based cogeneration in major sugar-producing states in India (MW)

State	*Potential* (MW)	*Commissioned till December 2000* (MW)
Andhra Pradesh	200	36.2
Gujarat	200	0.5
Karnataka	300	61.6
Punjab	150	12.0
Maharashtra	1000	9.0
Uttar Pradesh	1000	46.5
Others	300	9.0
Total	3500	272.8

Source

MNES. 2001. ***Renewable Energy in India: business opportunities***. New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.107 Biomass power and cogeneration status as on 31 December 2001

	Biomass power		*Cogeneration*		*Total*	
Project status	*MW*	*Number*	*MW*	*Number*	*MW*	*Number*
Commissioned	63.2	15	209.6	34	272.8	49
Under implementation	135.6	29	236.9	26	372.5	55

Source

MNES. 2001. ***Renewable Energy in India: business opportunities***. New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.108 Statewise and yearwise composition of commissioned biomass power cogeneration projects (MW): 1992/93 to 2000/01

State	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*
Andhra Pradesh	–	–	–	–	1.0	–	10.0	1	24.2
Gujarat	–	–	–	–	–	–	0.5	–	–
Haryana	4.0	–	–	–	–	–	–	–	–
Karnataka	–	–	–	–	1.0	–	10 0	26	24.6
Maharashtra	1.5	–	1.5	4.5	1.5	–	–	–	–
Madhya Pradesh	–	–	–	–	–	–	5.0	–	–
Punjab	–	10	–	–	–	–	–	–	2.0
Tamil Nadu	3.0	3	–	19.0	25.5	33.5	10.0	–	–
Uttar Pradesh	–	–	4.0	6.5	–	8.0	8.0	24	–
Total	8.5	13	5.5	30.0	29.0	41.5	43.5	51	50.8

Source
MNES. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.109 Statewise number and capacity of biomass gasifiers installed up to 31 December 2000

State / Union Territory	*Cumulative number of systems*	*Capacity* (kW)
Andhra Pradesh	230	14 684
Arunachal Pradesh	3	180
Assam	5	23
Bihar	2	20
Goa	3	22
Gujarat	200	3 921
Haryana	25	964
Himachal Pradesh	2	7
Jammu and Kashmir	4	120
Karnataka	-475	3 699
Kerala	10	615
Madhya Pradesh	140	4 429
Maharashtra	315	3 323
Orissa	16	72
Punjab	25	660
Rajasthan	21	218
Tamil Nadu	78	953
Uttar Pradesh	35	511
West Bengal	6	530
Andaman and Nicobar Islands	17	167
Delhi	16	74
Others	91	318
Total	1719	35 510

Source
MNES. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.110 Completed grid-interactive solar power projects

Project site	*Implementing organization*	*Capacity* (kW)
MNES-funded projects		
Village Saraisadi, Mau, UP (Uttar Pradesh)	Non-conventional Energy Development Agency	100
Village Kalyanpur, Aligarh, UP	Non-conventional Energy Development Agency	100
NEDA Building, Lucknow, UP	Non-conventional Energy Development Agency	25
Village SG Palayam, Coimbatore, Tamil Nadu	Tamil Nadu Electricity Board	25
Village SN Palayam, Coimbatore, Tamil Nadu	Tamil Nadu Electricity Board	25
Bidyut Bhavan, Kolkata, West Bengal	West Bengal Renewable Energy Development Agency	25
Jaitpura Kalan, Rajgarh, Madhya Pradesh	Madhya Pradesh Urja Vikas Nigam	100
Village Bajak, Mukhastar, Punjab	Punjab Energy Development Agency	50
Punjab Mini Secretariat, Chandigarh	Punjab Energy Development Agency	50
Harriya, Basti district, UP	Non-conventional Energy Development Agency	100
Vaidyuthi Bhavanam, Thiruvananthapuram, Kerala	Agency for Non-conventional Energy and Rural Technology	25
Kiltan Island, Lakshadweep	Electricity Department	100
Minicoy, Lakshadweep	Electricity Department	100
Non-MNES-funded projects		
Walhan dam, Lonawala, Maharashtra	Tata Electric Company	110
Kayathar wind farm, Tiruchirapalli, Tamil Nadu	Tamil Nadu Electricity Board	15
Udhaya Semiconductors Ltd, Coimbatore, Tamil Nadu	Udhaya Semiconductors Ltd	46
Village Vedembchari, Coimbatore, Tamil Nadu	NEPC India Ltd	100
Dr Reddy's Lab, Hyderabad, Andhra Pradesh	Dr Reddy's Laboratory	175
HDFC (Housing Development Finance Corporation) Building, Mumbai	HDFC	75
BHEL (Bharat Heavy Electricals Ltd) compound, Bangalore, Karnataka	BHEL	30
Steel Tubes of India Ltd, Dewas, Madhya Pradesh	Steel Tubes of India Ltd	239
Total		1615

Source
MNES. 2001. ***Renewable Energy in India: business opportunities.*** New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.111 Grid-interactive solar PV power projects under installation

Project site	*Implementing agency*	*Capacity* (kW)
UVN building, Bhopal, Madhya Pradesh	Madhya Pradesh Ujra Vikas Nigam	25
Bikalp Shakti Bhavan, Kolkata, West Bengal	West Bengal Renewable Energy Development Agency	25
Vidyut Sauda, Hyderabad, Andhra Pradesh	Andhra Pradesh Transmission Co.	100
Niel Island, Andaman and Nicobar Islands	Andaman and Nicobar Electricity Department	50
Long Island, Andaman and Nicobar Islands	Andaman and Nicobar Electricity Department	50
Total		250

Source
MNES. 2001. ***Renewable Energy in India: business opportunities.*** New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.112 Wind power installed capacity (MW): 2000 and 2001

State	*31 March 2000*			*31 March 2001*		
	Demonstration projects	*Private projects*	*Total capacity*	*Demonstration projects*	*Private projects*	*Total capacity*
Andhra Pradesh	3.1	85.0	88.1	5.4	86.5	91.9
Gujarat	17.3	149.6	166.9	17.3	149.6	166.9
Karnataka	2.6	31.7	34.3	2.6	42.0	44.6
Kerala	2.0	–	2.0	2.0	–	2.0
Madhya Pradesh	0.6	22.0	22.6	0.6	22.0	22.6
Maharashtra	6.4	72.8	79.2	6.4	183.4	189.8
Rajasthan	2.0	–	2.0	6.4	0.9	7.3
Tamil Nadu	19.4	751.4	770.8	19.4	793.2	812.6
West Bengal	–	–	–	0.5	–	0.5
Others	1.6	–	1.6	1.6	–	1.6

Source
http://www.windpowerindia.com/statstate.asp

Table 1.113 Wind power installed capacity (MW): 1991/92 to 2000/01

State	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*
Andhra Pradesh	0.55	0	0	5.43	38.93	9.40	1.50	6.00	26.25	3.86
Gujarat	14.52	1.63	10.63	37.75	51.16	31.14	20.10	0	0	0
Karnataka	0.55	0	0	0	2.03	3.27	11.17	2.63	14.60	10.34
Kerala	0	0	0	0	2.03	0	0	0	0	0
Madhya Pradesh	0.59	0	0	0	6.30	2.70	2.70	6.16	4.14	0
Maharashtra	1.10	0	0	1.50	0	2.77	0.23	23.34	50.35	110.52
Rajasthan	0	0	0	0	0	0	0	0	2.00	5.30
Tamil Nadu	22.31	11.07	50.47	190.87	281.68	119.77	31.14	17.77	45.68	41.87
West Bengal	0	0	0	0	0	0	0	0	0	0.50
Others	1.56	0	0	0	0	0	0	0	0	0
Total	41.18	12.70	61.09	235.54	382.11	169.03	66.83	55.89	143.00	172.42

Source
http://www.windpowerindia.com/statyear.asp

Table 1.114 Total generation from wind power projects (kWh): 31 December 2000

State	*Generation*
Andhra Pradesh	273 428 111
Gujarat	737 195 444
Karnataka	125 975 832
Kerala	11 987 911
Madhya Pradesh	68 444 570
Maharashtra	88 700 182
Orissa	1 174 856
Tamil Nadu	5 207 352 713
Rajasthan	4 651 098
Total	6 518 910 717

Source
MNES. 2001. ***Renewable Energy in India: business opportunities***. New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.115 Statewise cumulative generation from wind power projects in India (kWh): 1991/92 to 2000/01

State	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*
Andhra Pradesh	1 120 745	63 349	161 625	619 478	7 676 741	39 979 632	51 925 399	38 598 264	57 062 323	84 587 205
Gujarat	42 188 099	18 793 320	21 673 823	37 833 399	58 230 856	117 856 316	132 409 292	91 317 221	122 357 515	131 287 383
Karnataka	–	–	–	–	315 603	7 250 605	11 715 975	26 620 334	39 451 355	68 426 562
Kerala	–	–	–	59 146	2 041 468	2 565 150	1 867 326	1 584 744	1 930 689	1 939 388
Madhya Pradesh	1 080 146	406 900	336 059	250 906	813 273	5 977 195	7 426 841	10 508 979	19 243 954	24 377 577
Maharashtra	3 429 901	518 610	208 620	1 138 350	1 162 914	2 577 778	3 308 835	6 898 186	38 511 281	127 507 388
Orissa	1 174 856	–	–	–	–	–	–	–	–	–
Tamil Nadu	63 911 415	68 674 598	72 389 409	151 374 106	426 198 886	702 169 655	779 801 751	894 925 358	1 155 083 718	1 094 951 041
Rajasthan									766 650	5 154 525
Total	112 905 162	88 456 777	94 769 436	191 275 385	496 439 741	878 376 331	988 455 419	1 070 453 086	1 434 407 485	1 538 231 069

Source
http://www.windpowerindia.com/statcumul.asp

Table 1.116 Statewise wind monitoring stations in India: March 2001

State / Union Territory	*Total established stations*	*No. of stations in operation*	*Stations wih annual average WPD >150 W/m^2 at 30 m height*
State			
Andhra Pradesh	59	11	30
Arunachal Pradesh	4	–	–
Assam	5	–	–
Gujarat	56	11	34
Haryana	2	–	–
Himachal Pradesh	8	4	–
Jammu and Kashmir	7	3	–
Karnataka			
MNES Stations	33	11	17
KPCL Stations	19	–	8
Kerala	21	1	16
Madhya Pradesh	25	5	7
Maharashtra	66	17	27
Orissa	11	–	7
Punjab	11	–	–
Rajasthan	31	5	8
Tamil Nadu	60	10	40
Uttar Pradesh	11	–	1
West Bengal	9	2	2
Union Territory			
Andaman and Nicobar Islands	10	–	1
Lakshadweep	10	2	8
Pondicherry	4	–	–
Total	462	82	206

Source
http://www.windpowerindia.com/statstate.asp

Table 1.117 Wind monitoring stations with annual mean wind power density greater than 150 W/m^2: November 2000

Station	Location	*Annual mean wind speed* (kmph)		*Annual mean wind power density* (W/m^2)	
		Measured at 20–25 m	*Extrapolated at 30 m*	*Measured at 20–25 m*	*Extrapolated at 30 m*
Tamil Nadu					
Achankuttam	08°57' N, 77°28' E	18.6	20.0	270	335
Alagiyapandiyapuram	08°56' N, 77°39' E	20.9	22.3	301	371
Andhiyur	10°36' N, 77°11' E	19.1	20.6	177	213
Andipatti	09°59' N, 77°35' E	19.0	19.6	266	298
Arasanpalayam	10°51' N, 77°03' E	20.5	21.8	195	232
Ayikudy	09°00' N, 77°21' E	21.4	23.5	305	390
Edayarpalayam	10°55' N, 77°07' E	22.4	23.8	273	323
Ennore	13°16' N, 80°19' E	19.3	20.8	139	177
Gangaikondan	08°51' N, 77°35' E	18.4	19.0	246	267
Kannankulam	08°10' N, 77°46' E	21.3	22.2	238	268
Kattadimalai	08°14' N, 77°33' E	23.7	25.3	312	380
Kayattar I	08°58' N, 77°44' E	20.3	21.5	294	342
Kayattar II	08°57' N, 77°43' E	20.5	20.9	285	302
Kethanur	10°54' N, 77°13' E	21.1	22.3	259	305
Kumarapuram	08°16' N, 77°35' E	22.0	22.7	288	315
Mangalapuram	09°03' N, 77°22' E	22.3	23.4	312	357
Meenakshipuram	09°52' N, 77°18' E	16.4	17.5	224	267
Mettukadai	10°52' N, 77°23' E	18.0	19.2	184	221
Muppandal - I	08°16' N, 77°33' E	25.5	27.6	406	519
Muppandal - II	08°16' N, 77°33' E	23.1	26.5	306	444
Myvadi	08°36' N, 77°19' E	19.6	21.0	251	305
Naduvakkurichi	09°07' N, 77°30' E	16.8	18.0	157	190
Nettur	08°54' N, 77°33' E	19.9	20.2	338	358
Omankulum	08°58' N, 77°51' E	19.9	20.3	247	258
Ottapidaram	08°54' N, 78°01' E	18.5	20.0	221	280
Ovari	08°18' N, 77°53' E	18.2	19.2	160	184
Panakudi	08°19' N, 77°33' E	22.9	23.9	366	408
Pongalur	10°58' N, 77°21' E	19.1	20.4	213	251
Poolavadi	10°45' N, 77°61' E	21.2	23.0	283	343
Poosaripatti	10°41' N, 77°08' E	19.3	20.0	168	188
Puliyamkulam	08°19' N, 77°44' E	18.9	20.8	188	245
Rameshwaram	09°17' N, 79°20' E	23.9	26.4	290	398
Sankaneri	08°12' N, 77°40' E	22.6	23.4	258	287
Sembagaramanpudur	08°16' N, 77°31' E	21.7	23.0	300	367
Servallar hills	08°42' N, 77°21' E	17.8	19.9	207	247
Sultanpet	10°52' N, 77°11' E	19.0	19.1	203	204
Talayathu	08°48' N, 77°39' E	20.5	21.5	324	364
Thannirpandal	10°57' N, 77°19' E	18.2	21.0	216	330
Tuticorin	08°50' N, 78°08' E	17.6	19.0	148	185
Vakaikulam	08°45' N, 78°00' E	16.6	17.9	167	201

Continued

Table 1.117 continued

		Annual mean wind speed (kmph)		*Annual mean wind power density* (W/m²)	
Station	*Location*	*Measured at 20–25 m*	*Extrapolated at 30 m*	*Measured at 20–25 m*	*Extrapolated at 30 m*
Gujarat					
Adesar	23°33' N, 70°57' E	15.6	18.6	93	156
Amrapar (GIR)	21°10' N, 70°26' E	19.7	21.3	147	186
Amrapar (Seth)	21°44' N, 70°03' E	19.2	20.2	151	176
Bamanbore-II	22°26' N, 71°30' E	20.3	21.5	171	199
Bayath	22°56' N, 69°11' E	17.7	20.1	118	180
Bhandaria	22°06' N, 69°43' E	19.5	20.4	162	180
Dhank-I	21°48' N, 70°08' E	24.4	25.5	312	353
Dhank-II	21°48' N, 70°07' E	25.1	25.5	327	344
Godladhar	22°03' N, 71°20' E	19.5	22.5	144	216
Gala	22°19' N, 70°05' E	19.8	21.1	175	205
Haripar	22°20' N, 69°38' E	20.1	21.2	160	186
Harshad	21°50' N, 69°22' E	20.0	21.4	164	193
Jafrabad	20°53' N, 71°25' E	17.5	19.1	137	176
Jamanvada	23°35' N, 68°36' E	18.6	20.7	149	202
Kalyanpur	22°03' N, 69°24' E	22.1	23.7	208	253
Kera	23°04' N, 69°36' E	19.4	20.4	135	156
Kukma	23°11' N, 69°47' E	19.2	20.6	150	184
Lamba	21°54' N, 69°19' E	20.0	21.1	164	191
Limbara	22°32' N, 70°59' E	19.1	20.1	166	190
Mesaria	22°28' N, 71°06' E	18.8	19.9	131	154
Moti sindholi	23°11' N, 68°43' E	17.5	20.4	118	180
Mundra	22°47' N, 69°43' E	19.5	21.3	168	217
Nani Kundal	21°55' N, 71°28' E	20.0	21.9	163	209
Navadra	21°57' N, 69°16' E	20.8	22.4	183	226
Navi bandar	21°26' N, 69°47' E	19.5	20.5	153	176
Okha	22°28' N, 69°03' E	19.4	20.6	150	191
Okhamadhi	22°06' N, 69°06' E	19.0	20.2	129	159
Poladiya	23°06' N, 69°12' E	20.4	22.0	174	215
Ratabhe	22°56' N, 71°02' E	17.5	19.4	123	154
Sanodar	21°35' N, 72°11' E	22.5	24.2	197	254
Sinai	23°03' N, 70°04' E	20.8	21.8	183	207
Surajbari	23°14' N, 70°39' E	19.5	22.0	184	268
Orissa					
Chandipur	21°32' N, 87°01' E	15.2	18.5	120	179
Chatrapur	19°18' N, 84°58' E	14.4	16.5	106	158
Damanjodi	18°49' N, 83°00' E	16.6	17.6	129	154
Gopalpur	19°16' N, 84°54' E	16.2	18.1	124	173
Paradip	20°23' N, 86°41' E	18.2	20.1	153	201
Puri	19°48' N, 86°49' E	17.5	18.8	137	166

Continued

Table 1.117 continued

		Annual mean wind speed (kmph)		*Annual mean wind power density* (W/m²)	
Station	*Location*	*Measured at 20–25 m*	*Extrapolated at 30 m*	*Measured at 20–25 m*	*Extrapolated at 30 m*
Maharashtra					
Alamorabhu Pathar	16°46' N, 74°23' E	20.5	21.1	164	178
Chalkewadi	71°36' N, 73°49' E	20.2	20.6	206	211
Dhalgaon	17°08' N, 74°59' E	21.2	21.9	216	234
Dongerwadi	16°55' N, 74°48' E	20.1	21.1	167	190
Gawalwadi	20°06' N, 73°43' E	18.0	19.1	127	164
Gude Panchgani	17°07' N, 73°59' E	19.8	21.3	178	223
Kas	17°44' N, 73°49' E	19.1	20.0	173	189
Kavdya Donger	19°01' N, 74°32' E	22.0	22.1	209	222
Khandke	19°08' N, 74°53' E	19.6	21.3	146	187
Kolgaon	18°50' N, 74°43' E	20.5	21.0	177	190
Kotholi	16°58' N, 73°59' E	17.8	18.1	164	171
Lonavla	18°47' N, 73°23' E	15.5	17.7	122	176
Mandhardeo	18°02' N, 73°53' E	19.0	19.1	153	163
Matrewadi	17°12' N, 73°56' E	20.8	21.1	211	218
Motha	21°24' N, 77°22' E	18.7	19.1	146	154
Panchgani	17°55' N, 73°48' E	18.4	19.7	133	160
Sautada	18°48' N, 75°20' E	21.2	21.9	167	182
Thoseghar	17°55' N, 73°53' E	21.7	23.3	229	287
Vankusawade	17°27' N, 73°50' E	21.2	21.7	231	247
Varekarwadi	17°13' N, 73°59' E	21.0	21.5	257	264
Vijayadurg	16°30' N, 73°20' E	19.6	20.6	207	225
Andhra Pradesh					
Badhrampalli Kottala	14°55' N, 77°24' E	21.3	21.5	248	255
Badhrampalli	15°01' N, 78°04' E	20.8	21.6	240	265
Bhimunipatnam	17°54' N, 83°27' E	19.1	20.1	195	229
Borampalli	14°30' N, 77°09' E	19.4	20.0	163	176
Burugala	15°08' N, 77°57' E	18.4	19.1	147	163
Chinnababayapalli	13°57' N, 77°37' E	18.5	19.9	132	171
Jamalamadugu I	14°49' N, 78°23' E	17.5	18.3	161	184
Jamalamadugu II	14°46' N, 78°22' E	18.6	19.4	165	183
Jangamguntla	15°39' N, 79°08' E	16.0	16.6	149	164
Kadavakallu	14°48' N, 77°56' E	22.1	22.3	303	308
Kakulakonda	13°43' N, 79°21' E	23.1	25.0	332	404
Kondamithepalli	15°03' N, 78°03' E	21.2	22.0	252	282
MPR Dam	14°54' N, 77°25' E	19.9	20.7	228	245
Mustikovala	14°15' N, 77°32' E	20.2	20.8	201	216
Mudugupalli	14°42' N, 77°51' E	19.3	20.1	169	187
Nallakonda	14°07' N, 77°34' E	22.8	23.1	276	288
Narasimhakonda	14°30' N, 79°52' E	20.1	22.5	186	261
Nazeerabad	17°11' N, 77°55' E	21.0	21.6	176	189

Continued

Table 1.117 continued

		Annual mean wind speed (kmph)		*Annual mean wind power density* (W/m²)	
Station	*Location*	*Measured at 20–25 m*	*Extrapolated at 30 m*	*Measured at 20–25 m*	*Extrapolated at 30 m*
Pampanoor Thanda	14°38' N, 77°24' E	19.6	20.1	182	194
Payalakuntla	14°53' N, 79°02' E	20.1	20.4	230	241
Puttaparthy	14°09' N, 77°48' E	17.7	18.0	149	156
Ramagiri I	14°17' N, 77°31' E	19.5	20.9	205	246
Ramagiri III	14°22' N, 77°32' E	19.4	20.2	190	213
Singanamala	14°46' N, 77°44' E	23.8	24.2	366	377
Talaricheruvu	14°57' N, 78°03' E	18.1	19.3	144	179
Tallimadugula	14°22' N, 77°32' E	22.2	22.5	260	267
Tirumala	13°40' N, 79°22' E	20.4	21.9	226	282
Tirumalayapalli	14°54' N, 78°11' E	19.0	20.8	154	195
Vajrakarur	14°58' N, 77°11' E	19.5	20.9	173	205
Rajasthan					
Damotar	24°07' N, 74°44' E	18.8	19.5	149	163
Devgarh	24°02' N, 74°39' E	19.9	21.4	151	186
Harshnath	27°29' N, 75°10' E	20.6	22.6	206	277
Jaisalmer	26°54' N, 70°55' E	17.8	19.5	159	202
Jaswanthgad	24°47' N, 73°28' E	18.9	19.4	142	152
Khodal	26°22' N, 71°13' E	17.0	18.5	135	170
Mohangarh	27°17' N, 71°13' E	15.5	17.5	117	161
Phalodi	27°07' N, 72°20' E	17.4	19.2	142	185
Lakshadweep					
Agathi	10°51' N, 72°11' E	18.4	19.5	179	208
Amini	11°07' N, 72°44' E	17.4		140	
Bitra	11°35' N, 72°12' E	16.5	19.3	173	
Chetlat	11°43' N, 72°43' E	19.0	20.0	172	
Kadmat	11°13' N, 72°47' E	18.0	19.4	169	211
Kalpeni	10°05' N, 73°39' E	16.2	18.9	125	182
Kavarathi	10°33' N, 72°38' E	18.0	19.6	161	206
Minicoy	08°17' N, 73°04' E	17.4	>17.4	162	>162
Karnataka					
B.B.Hills	13°26' N, 75°45' E	26.8	27.6	498	532
Bommanahalli	13°17' N, 76°30' E	18.1	19.4	128	151
Chikodi	16°20' N, 74°30' E	23.2	23.5	264	272
Chalamatti	15°18' N, 75°03' E	21.4	22.9	189	230
Godekere	13°20' N, 76°40' E	19.8	19.9	155	157
Gokak	16°07' N, 74°47' E	19.2	21.4	168	228
Hanamsagar	15°54' N, 76°02' E	20.6	22.1	173	210
Hanumanhatti	15°55' N, 74°43' E	20.3	22.1	165	213
Haradenahalli	12°51' N, 76°13' E	18.5	19.7	127	151

Continued

Table 1.117 continued

		Annual mean wind speed (kmph)		*Annual mean wind power density* (W/m²)	
Station	*Location*	*Measured at 20-25 m*	*Extrapolated at 30 m*	*Measured at 20–25 m*	*Extrapolated at 30 m*
Horti	17°05' N, 75°40' E	19.8	20.1	173	180
Jogimatti	14°10' N, 76°22' E	30.3	31.3	498	553
Khamkarkatti	15°45' N, 74°35' E	20.3	20.8	159	169
Khanderayanahalli	14°30' N, 75°45' E	20.2	20.3	183	185
Malgatti	15°52' N, 75°55' E	19.6	21.9	156	219
Mannikeri	16°58' N, 74°28' E	24.3	25.2	252	278
Sangundi	16°15' N, 75°44' E	18.7	20.4	153	193
Sogi	14°54' N, 75°59' E	23.8	24.1	246	255
Somadevarahatti	16°53' N, 75°31' E	17.5	18.7	131	155
Arasinagundi	14°29' N, 76°50' E	27.0	27.0	392	392
Bullenahalli - I (KPCL)	13°25' N, 76°40' E	21.2	21.2	168	168
Bullenahalli - II (KPCL)	13°24' N, 76°41' E	20.3	20.3	195	195
Gujannur (KPCL)	14°58' N, 75°54' E	23.4	23.4	240	240
Jogimatti (KPCL)	14°11' N, 76°25' E	31.0	31.0	582	582
Madekeripura (KPCL)	14°13' N, 76°27' E	27.1	27.1	365	365
Sogi - A (KPCL)	14°55' N, 75°59' E	26.6	26.6	415	415
Sogi - B (KPCL)	14°54' N, 75°59' E	24.5	24.5	271	271
Kerala					
Kanjikode	10°47' N, 76°49' E	22.6	23.7	218	249
Kolahalamedu	09°40' N, 76°56' E	16.9	17.8	146	174
Kottamala	10°40' N, 76°36' E	19.2	20.5	154	187
Kottathara	11°07' N, 76°39' E	19.7	20.7	207	243
Kulaathummedu	09°44' N, 77°13' E	19.1	22.0	180	239
Kuttikanam	09°35' N, 76°59' E	16.5	18.0	140	181
Panchalimedu	09°32' N, 76°57' E	20.2	20.9	258	285
Parampukettimedu	09°54' N, 77°13' E	26.4	28.4	447	528
Ponmudi	09°46' N, 77°08' E	18.1	18.7	216	220
Pullikanam	09°44' N, 76°52' E	18.2	18.5	178	187
Ramakalmedu	09°49' N, 77°14' E	29.7	29.7	532	534
Sakkulattumedu	09°52' N, 77°13' E	28.6	28.6	531	533
Senapathi	09°57' N, 77°00' E	19.3	20.7	192	233
Tolanur	10°42' N, 76°30' E	15.7	17.2	115	157
Madhya Pradesh					
Jamgodrani	22°59' N, 76°10' E	18.2	19.7	130	164
Kheda	22°36' N, 75°38' E	18.5	19.7	126	152
Kukru	21°30' N, 77°29' E	19.0	20.4	157	194
Mahuria	23°50' N, 76°06' E	19.0	19.5	171	182
Mamatkheda	23°45' N, 75°03' E	20.0	21.5	169	202
Nagda	22°53' N, 76°03' E	22.5	23.5	219	249
Sendhva	21°38' N, 75°03' E	18.1	19.1	163	183

Continued

Table 1.117 continued

		Annual mean wind speed (kmph)		*Annual mean wind power density* (W/m²)	
Station	*Location*	*Measured at 20-25 m*	*Extrapolated at 30 m*	*Measured at 20-25 m*	*Extrapolated at 30 m*
West Bengal					
Fraserganj	21°34' N, 88°15' E	17.7	18.5	147	158
Gangasagar	21°37' N, 88°04' E	17.4	18.1	155	173
Andaman and Nicobar Islands					
Keating Point	09°15' N, 92°46' E	16.1	19.1	114	175
Uttar Pradesh					
Bachelikhal	30°04' N, 78°37' E	18.1	20.0	144	181

Source
http://www.windpowerindia.com/statwind2.asp

Table 1.118 Extractable wind energy potential and possible installed capacities at 30-m height in 10 states

	1% availability of land			*2% availability of land*			
State	*Extractable potential* (MW)	*Extractable energy units* (MWh/year)	*Installed capacity* (MW)	*Extractable potential* (MW)	*Extractable energy units* (MWh/year)	*Installed capacity* (MW)	*Technical availability with 20% of grid as on 31 March 2000* (MW)
Andhra Pradesh	1352	11.8	6389	2703	23.70	12777	1251
Gujarat	1171	10.3	5935	2341	20.50	11870	1446
Karnataka	1763	15.4	7958	3525	30.90	15915	873
Kerala	196	1.7	890	392	3.44	1779	423
Madhya Pradesh	730	6.4	3967	1222	10.70	7933	871
Maharashtra	400	3.5	2156	801	7.01	4312	2478
Orissa	236	2.1	1343	473	4.14	2687	398
Rajasthan	558	4.9	3172	1116	9.78	6343	497
Tamil Nadu	763	6.7	2931	1526	13.40	5862	1210
West Bengal	15	0.1	88	31	0.27	175	875
Total	7184	62.9	34827	14129	124.00	69655	10322

Source
Wind Power Producers Association. 2001. *Windpro* No. 43 (May 2001). Chennai: Wind Power Producers Association

Table 1.119 Extractable wind energy potential and possible installed capacities at 50-m height in 10 states

	1% availability of land			*2% availability of land*			
State	*Extractable potential* (MW)	*Extractable energy units* (MWh/year)	*Installed capacity* (MW)	*Extractable potential* (MW)	*Extractable energy units* (MWh/year)	*Installed capacity* (MW)	*Technical availability with 20% of grid as on 31 March 2000* (MW)
Andhra Pradesh	1823	16.0	9063	3646	31.94	18126	1251
Gujarat	1581	13.9	7362	3162	27.7	14724	1446
Karnataka	1559	13.7	7161	3117	27.3	14321	873
Kerala	204	1.8	1026	407	3.57	2053	423
Madhya Pradesh	926	8.1	4978	1853	16.23	9957	871
Maharashtra	911	8.0	4519	1823	15.97	9038	2478
Orissa	216	1.9	1120	432	3.78	2240	398
Rajasthan	1253	11.0	6672	2506	21.95	13344	497
Tamil Nadu	933	8.2	4159	1865	16.34	8319	1210
West Bengal	6	0.5	32	11	0.99	64	875
Total	9411	82.4	46092	18822	165.78	92187	10322

Source

Wind Power Producers Association. 2001. *Windpro* No. 43 (May 2001). Chennai: Wind Power Producers Association

Table 1.120 Small hydro potential sites (up to 25 MW) capacity identified in India

State / Union Territory	*No. of identified sites*	*Total capacity* (MW)
State		
Andhra Pradesh	286	254.63
Arunachal Pradesh	492	1 059.03
Assam	46	118.00
Bihar and Jharkhand	171	367.97
Gujarat	290	156.83
Haryana	22	30.05
Himachal Pradesh	323	1 624.78
Jammu and Kashmir	201	1 207.27
Karnataka	230	652.61
Kerala	198	466.85
Madhya Pradesh and Chattisgarh	125	410.13
Maharashtra	234	599.47
Manipur	96	105.63
Meghalaya	98	181.50
Mizoram	88	190.32
Nagaland	86	181.39
Orissa	161	156.76
Punjab	78	65.26
Rajasthan	49	27.26
Sikkim	68	202.75
Tamil Nadu	147	338.92
Tripura	8	9.85
Uttar Pradesh and Uttaranchal	445	1 472.93
West Bengal	145	182.62
Union Territory		
Andaman and Nicobar Islands	6	6.40
Goa	3	2.60
Total	4 096	10 071.81

Source
MNES. 2001. ***Renewable Energy in India: business opportunities.*** New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.121 Different categories of urban municipal and industrial wastes and their estimated quantity

Wastes	*Estimated quantity*
Municipal solid waste	30 million tonnes/year
Municipal liquid waste	12 000 million litres/day[a]
Distillery (243 units)	8 057 kilolitres/day
Pressmud	9 million tonnes/year
Food and fruit processing wastes	4.5 million tonnes/year
Willow dust	30 000 tonnes/year
Dairy industry waste	50–60 million litres/day
Paper and pulp industry waste (300 mills)	1.6×10^3 m^3/day
Tannery (2000 units)	52 500 m^3 waste water/day

[a] 212 Class I and II cities

Source
MNES. 2001. ***Renewable Energy in India: business opportunities.*** New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.122 Urban and industrial waste projects completed, under execution, and under development

Project	*Site*
Completed	
2.75-MW power generation plant using rice husk as fuel	Gowthami Solvent Oil Mills Ltd, Tanuku, Andhra Pradesh
1-MW power generation plant using biogas generated from distillery spent-wash	K M Sugar Mills (Distillery Unit), Faizabad, Uttar Pradesh
2-MW power generation plant using biogas produced from distillery spent-wash	Kanoria Chemicals & Industries Ltd, Ankleshwar, Gujarat
2.7-MW power generation plant using biogas produced from distillery spent-wash	Som Distilleries Ltd, Bhopal, Madhya Pradesh
0 4-MLD Biomethanation plant for treatment of sewage	Regional Research Laboratory, Bhubaneswar
Biomethanation system for treatment of black liquor (10 000 m^3 biogas/day)	Setia Paper Mills Ltd, Muksar, Punjab
0.3-MW power project using 60 TPD biomethanation for treatment of abattoir waste 4000 m^3 biogas/day	Alka Beer Exports Ltd, Medak, Andhra Pradesh
1-MW power generation project using biogas produced from distillery effluent	Ugar Sugar Mills, Belgaum, Karnataka
5-TPD capacity biomethanation plant for treatment of tannery flashing and sludge from tannery effluent plant	Tanners Cooperative, Tamil Nadu
8000 m^3/day biogas plant using waste from starch and glucose manufacturing units	Vensa Biotech Ltd, Samalkot, Andhra Pradesh
300 m^3/day biogas methanation plant treating solid wastes of leather industry	Tata International Ltd, Dewas, Madhya Pradesh
Under execution	
4-MW power plant based on biomethanation of MSW	Nagpur, Maharashtra
210-TPD pelletization project using garbage at Hyderabad city	SELCO International, Hyderabad, Andhra Pradesh
1.2 MW power plant using poultry wastes	G K Bioenergy Systems, Chennai, Tamil Nadu
Under development	
200-TPD capacity pelletization project from city garbage	Hyderabad, Andhra Pradesh
5-MW power generation plant using city garbage	Lucknow, Uttar Pradesh
14.85-MW power generation plant based on gasification of MSW	Chennai, Tamil Nadu
4800 m^3/day biogas plant using starch waste	Anil Starch Ltd, Ahmedabad
1-MW power generation project using biogas	KCP Sugar Mills, Andhra Pradesh

MLD - million litres per day; TPD - tonnes per day; MSW - municipal solid waste

Source
MNES. 2001. ***Renewable Energy in India: business opportunities.*** New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.123 Urban and industrial waste projects (MW)

State	*Power*	*Project/company*
Andhra Pradesh	2.75	Gowthami Solvent Oil Mills Ltd, Tanuku
Andhra Pradesh	0.30	Alka beer Exports Ltd, Medak
Gujarat	2 00	Kanoria Chemicals & Industries Ltd, Ankleshwar
Karnataka	1.00	Ugar Sugar Mills, Belgaum
Madhya Pradesh	2.70	Som Distilleries Ltd, Bhopal
Punjab	0.75	Setia Paper Mills Ltd, Muksar
Uttar Pradesh	10.00	KM Sugar Mill Distillery Unit, Faizabad

Source
MNES. 2001. ***Renewable Energy in India: business opportunities.*** New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.124 National project on biogas development statewise coverage up to 1999/2000 and achievements and targets: 2000/01 (**no. of plants**)

State / Union Territory / Agency	*Potential*	*Installed up to 1999/2000*	*Coverage of potential* (%)	*2000/01*	
				Annual target	*Achievement April–December 2000*
State					
Andhra Pradesh	1 065 600	282 746	27	25 000	16 037
Arunachal Pradesh	7 500	742	10	300	155
Assam	307 700	41 896	14	750	61
Bihar	939 900	116 621	12	1 000	271
Goa	8 000	3 188	40	300	68
Gujarat	554 000	335 315	61	8 000	1 366
Haryana	300 000	39 865	13	2 500	1 209
Himachal Pradesh	125 600	42 554	34	650	345
Jammu and Kashmir	128 500	1 862	1	200	–
Karnataka	680 000	277 585	41	20 000	16 656
Kerala	150 500	64 834	43	1 500	764
Madhya Pradesh	1 491 200	178 304	12	14 000	3 879
Maharashtra	897 000	647 538	72	12 000	6 128
Manipur	38 700	1 793	5	600	146
Meghalaya	24 000	1 279	5	300	–
Mizoram	2 200	1 976	90	400	360
Nagaland	6 700	1 097	16	800	–
Orissa	605 500	160 010	26	10 000	6 415
Punjab	411 600	56 348	14	6 500	3 673
Rajasthan	915 300	65 185	7	750	371
Sikkim	7 300	2 494	34	600	179
Tamil Nadu	615 800	196 522	32	2 000	711
Tripura	28 500	1 163	4	250	151
Uttar Pradesh	2 021 000	340 312	18	10 000	5 717
West Bengal	695 000	168 297	24	15 000	8 285
Union Territory					
Andaman and Nicobar Islands	2 200	137	6	–	–
Chandigarh	1 400	97	7	–	–
Dadra and Nagar Haveli	2 000	169	8	–	–
Delhi	12 900	673	5	–	–
Pondicherry	4 300	539	13	–	–
Agency					
KVIC, Mumbai	–	–	–	35 000	16 753
AIWC, New Delhi	–	–	–	1 500	316
SDA, Kanjirapally	–	–	–	10 000	7 975
Total	12 049 900	3 031 141	25	179 910	97 991

KVIC – Khadi and Village Industries Commission; NDDB – National Diary Development Board; AIWC – All India Women's Conference; SDA – Sustainable Development Agency

Source

MNES. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Non-conventional Energy Sources.

Table 1.125 Statewise and agencywise achievements as against targets for 2000/01 under the National Programme on Improved Chulhas

	No. of chulhas			
	Annual target		*April-December 2000*	
State / Union Territory / Agency	*No. of villages*	*No. of* chulhas	*Target*	*Achievement*
State				
Andhra Pradesh	850	150 000	75 000	80 323
Arunachal Pradesh	100	5 000	2 500	–
Assam	400	20 000	10 000	983
Bihar	140	25 000	12 500	1 549
Delhi	12	2 000	1 000	–
Goa	100	5 000	2 500	–
Gujarat	540	100 000	50 000	29 362
Haryana	350	62 500	31 250	–
Himachal Pradesh	8	1 100	550	711
Jammu and Kashmir	100	60 000	30 000	–
Karnataka	350	50 000	25 000	12 195
Kerala	430	81 000	40 500	7 620
Madhya Pradesh	650	40 000	20 000	782
Maharashtra	2 080	115 000	57 500	17 675
Manipur	100	5 000	2 500	1 218
Meghalaya	100	5 000	2 500	–
Mizoram	150	7 500	3 750	–
Nagaland	150	7 500	3 750	–
Orissa	970	200 000	100 000	98 144
Punjab	375	65 000	32 500	26 100
Rajasthan	175	17 400	38 700	7 797
Sikkim	100	5 000	2 500	2 785
Tamil Nadu	340	60 000	30 000	28 902
Tripura	100	5 000	2 500	3 702
Uttar Pradesh	1 000	175 000	87 500	6 080
West Bengal	2 050	375 000	187 500	173 275
Union Territory				
Andaman and Nicobar Islands	8	1 200	600	786
Dadra and Nagar Haveli	5	500	250	–
Lakshadweep	2	200	100	12
Pondicherry	15	3 000	1 500	1 720
Agency				
KVIC	1 875	328 000	164 000	156 996
AIWC	225	25 000	12 500	14 400
Total	13 850	2 000 000	1 000 000	673 117

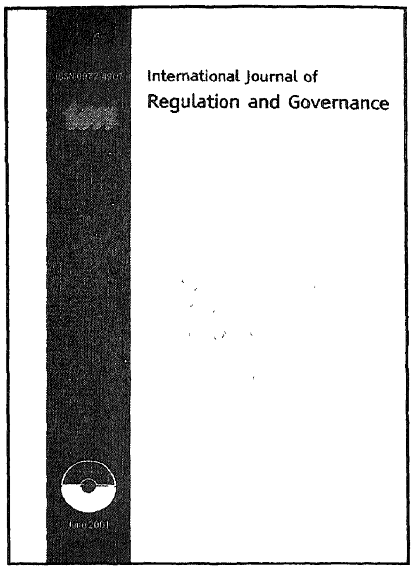
KVIC - Khadi and Village Industries Commission; AIWC - All India Women's Conference

Source

MNES. 2001. ***Annual Report 2000/01.*** New Delhi: Ministry of Non-conventional Energy Sources.

International Journal of Regulation and Governance

This journal is intended to provide a forum for comprehensive investigation, analysis, and review of such sectors as energy, telecommunications, water, environment and transport. Broadly, it will cover issues related to tariff, demand forecasting, competition, institutional, and market structures and other related issues that confront decision makers, planners, consultants, and researchers. It is published twice a year, in June and December.



Editorial board

Mr Ian Alexander, The World Bank, Singapore
Mr Ashley C Brown, Harvard University, USA
Dr Anton Eberhard, University of Cape Town, South Africa
Dr Michelle Michot Foss, University of Houston, USA
Prof. M Nurul Islam, Bangladesh University of Engineering and Technology, Bangladesh
Dr Raymond Lawton, The Ohio State University, USA
Prof. Mohan Munasinghe, University of Colombo, Sri Lanka
Dr R K Pachauri, Tata Energy Research Institute, India
Prof. S L Rao, Chairman, Forum of Indian Regulators, India
Prof. Dr Lineu Belico dos Reis, Polytechnic (Engineering) School of Sao Paulo University, Brazil
Prof. Rohan Samarajiva, Delft University, The Netherlands
Dr E A S Sarma, Principal, Administrative Staff College of India, India
Mr S Sundar, Tata Energy Research Institute, India
Mr Steve Thomas, University of Greenwich, UK

- **Price Rs 1000 / US $30 (annual subscription)**

All orders and enquiries to

TERI
Information Dissemination Services
Darbari Seth Block, Habitat Place
Lodhi Road, New Delhi- 110 003

Fax +91 11 468 2144 or 468 2145
E-mail outreach@teri.res.in
Telephone +91 11 468 2100 or 468 2111
Web site www.teriin.org

Visit our online catalogue at www.teriin.org/pub/

ENERGY DEMAND

Agriculture

At a glance

- Agriculture is the largest sector of the Indian economy employing 68% of the total workforce.
- The contribution of agriculture and allied sector to the total GDP (gross domestic product) has declined from 59% in 1950/51 to 27% in 1999/2000.
- The average annual growth rate of agriculture and allied sectors was 3.9% during 1980 to 1991 and 3.6% during the post-reform period of 1992 to 2000.
- 209 MT (million tonnes) of foodgrains was produced.
- The performance of pulses, oilseed crops, sugar cane, and other commercial crops was lower than that of the previous year.
- Since 1970s, the net area sown has remained constant at around 140 million hectares.
- Nearly two-thirds of the area under foodgrain crops are under just two crops–rice and wheat.
- In 1999/2000, the country received about 92% of the normal rainfall.
- The total water use for irrigation constituted 84% of the total water use.
- In 1998/99, 78 million hectares of land was under high-yielding varieties.
- Fertilizer (NPK [nitrogen, phosphorus, and potassium]) consumption in India has increased from 0.5 MT in 1963/64 to 18.1 MT in 1999/2000.
- The per hectare NPK consumption (75 kg/ha) is one of the lowest in the world.
- The consumption of pesticides decreased from 75 000 tonnes in 1990/91 to 49 160 tonnes in 1998/99.
- Land preparation, harvesting, and irrigation activities consume most of the energy used in agriculture.
- The share of muscle power in agriculture has decreased from 93% in 1950/51 to 20% in 1995/96.
- Although farm mechanization has increased with time, the increase in yield levels does not reflect the proper use of energy.
- Economic growth, population explosion, and shifts in the dietary pattern are all changing the supply and demand profile of food.

Introduction

Agriculture is the largest sector of economic activity in India. According to the 1991 census, 68% of the workforce was employed in this sector. The contribution of agriculture and allied sectors to the total gross domestic product has declined from 59% in 1950/51 to 27% in 1999/2000 (1993/94 prices). The average annual growth rate of agriculture and allied sectors was 3.9% during 1980–91 and 3.6% during the post-reform period of 1992–2000.

The total foodgrain production has increased from 51 MT (million tonnes) in 1950/51 to a record level of 209 MT in 1999/2000, with an annual buffer stock of 20–30 MT during the 1990s. This remarkable achievement was made possible through the modernization of agriculture, which began with the introduction of dwarf wheat varieties in the early 1960s. An increase of 17 MT over 1997/98 is impressive considering that rainfall in 1999/2000 was below normal in some regions. This was possible largely due to the increased contribution by rabi crops. The rabi season is characterized by assured irrigation and lower incidence of pests and diseases, conditions that favour higher production. In 1999/2000, rice production touched a new high of 89.5 MT, and wheat also registered an increase of 4.3 MT over the previous year's production. The combined contribution of rice and wheat to the total foodgrain production was 76%, and that of pulses was 6%–7%. However, the performance of pulses, oilseed crops, sugarcane, and other commercial crops was lower than that during the previous year.

Agriculture Inputs

Land

In the last 10 years, the net area sown has remained constant at around 142 Mha (million hectares). The area under foodgrains accounts for 65% of the total gross cropped area and that under oilseed and other commercial crops 13% and 8%, respectively. Nearly two-thirds of the area under foodgrain crops is under rice and wheat. India has reached a plateau as far as the area under agriculture is concerned. Therefore, any future increase in the food production has to come from the vertical expansion. Increased cropping intensity and enhanced yields may hold the key to enhanced food production in the country.

Water

Indian agriculture is susceptible to changes in climate, especially precipitation, as 70% of the cultivated area is rainfed. The distribution of the monsoons is highly erratic over space and time. In 1999/2000, India received about 92% of its normal quota of rainfall. The food production of kharif crops increased despite the deficit in rainfall mainly due to residual moisture; however, the deficit in rainfall may affect this year's food production.

The total water used for irrigation in the country is 943 billion cubic metres, constituting 84% of the total water used in the country (MoF 2001). The creation of an irrigation potential, the total area that can be irrigated, has received top priority in government planning, and it has increased from 22.6 Mha in 1950/51 to 94.7 Mha in 1999/2000. Out of 94.7 Mha, 35.3 Mha is accounted for by major and medium irrigation projects and 59.4 Mha by minor irrigation projects. The land under irrigation continues to increase and the ultimate irrigation potential has been reassessed to be 139.89 Mha.

Seeds

The availability of quality/certified seeds is crucial for successful agriculture. The distribution of certified seeds has been increasing over time. The distribution of certified seeds has increased from 0.57 MT in 1990/91 to 0.83 MT in 1998/99. Availability of better quality seeds has brought more area under HYVs (high-yielding varieties). The area under HYVs has increased from 65 Mha in 1990/91 to 78 Mha in 1998/99. Nearly 73% of the area under HYVs is under rice and wheat. Both private and public sectors are the major players in the country's seed industry. The private sector's share is more than 60% while the combined share of public sector and unorganized sector is around 40% in terms of value of seed distributed. The future growth in the share of the private sector depends largely on the policies the government will pursue to ensure timely availability of good quality seeds to the farmer.

Fertilizers

Modern agriculture largely depends on the use of high-cost inputs, including concentrated fertilizers. The nitrogen (N), phosphorus (P), and potassic (K) fertilizer consumption in India has increased from 0.5 MT in 1963/64 to 18.1 MT in 1999/2000. Despite India being the third largest consumer of fertilizers (after China and the US, respectively), the per hectare consumption of NPK (75 kg/ha) is one of the lowest in the world. The fertilizer production of 14.3 MT during 1999/2000 fell short of the consumption by 3.8 MT. Against the expected NPK consumption ratio of 4:2:1, the actual consumption ratio is extremely variable in different parts of the country. Therefore, the proportion of nutrients to be used in different part of the country has to be reconsidered based on inherent soil fertility and crop needs. Besides this, low fertilizer use-efficiency and declining trend in crop responses to nutrients are major concerns. Greater use of biofertilizers should be encouraged as further increases in chemical fertilizer application may be expensive and environmentally unfriendly.

Pesticides

The use of pesticides has become indispensable for modern agriculture. The consumption of technical-grade pesticides has increased from 8620 tonnes in 1960/61 to 75 000 tonnes in 1990/91. Although the per hectare consumption of pesticides in India (300 g) is lower than that of the US (1 kg) and Japan (10–12 kg), several pesticide-induced pest outbreaks have been reported from various parts of the country. Indiscriminate use of pesticides has resulted in the loss of biodiversity of natural enemies, secondary pest outbreaks, development of resistance to pesticides, food contamination, adverse health impacts, and ecosystem damage. Out of 133 registered pesticides, 34 are either banned or restricted in developed countries. Therefore, since the early 1990s, the emphasis has been on integrated pest management (combination of chemical and biological methods). Timely sowing, use of biocontrol agents, and need-based application of chemical pesticides has resulted in reduction in the consumption of technical-grade pesticides from 75 000 tonnes in 1990/91 to 49 160 tonnes in 1998/99. This trend is a positive move towards sustainable agriculture.

Energy use

Three activities, namely land preparation, harvesting and irrigation, consume most of the energy used in agriculture. While harvesting and land preparation consume most of the diesel, electricity is largely used for irrigation purposes. The extent of energy use depends on the quality and quantity of inputs and the efficiency of the various sub-systems involved. Subsistence agriculture is less energy-intensive compared with commercial agriculture. The main crops, in the decreasing order of their energy requirements, are as follows: rice, sugar cane, potato, groundnut, wheat, maize, sorghum, gram, and castor. Two crops, rice and wheat, account for one-third of the total energy consumption. Enhanced use of high-yielding seeds, synthetic fertilizers, irrigation, agro-chemicals, and agricultural machines have rendered modern agriculture highly energy-intensive. Consequently, the quantities of diesel and electricity used have increased over time, but their relative shares in total energy consumption have remained constant (Table I).

The share of human labour and animal power in the total energy consumption for agriculture has decreased from 93% in 1950/51 to 20% in 1995/96, indicating progress in farm mechanization (Figure 1). Consequently, the working bovine stock has decreased from 81 million in 1971/72 to 13 million in 1991/92.

India, with an annual production of 0.25 million tractors, is the largest producer of tractors in the world. Besides tractors, 0.7 million pump

Table I Share of oil and electricity in the final commercial energy consumption in the agricultural sector (peta calories)

Year	*Oil*	*Electricity*	*Total*
1970/71	6.88 (64.15)	3.84 (35.85)	10.72 (100)
1975/76	14.23 (65.49)	7.50 (34.51)	21.73 (100)
1980/81	27.94 (69.16)	12.46 (30.84)	40.40 (100)
1984/85	39.65 (68.75)	18.03 (31.25)	57.68 (100)
1987/88	47.05 (64.44)	25.96 (35.56)	73.01 (100)

Note Figures in parentheses indicate percentages.
Source Planning Commission (1993)

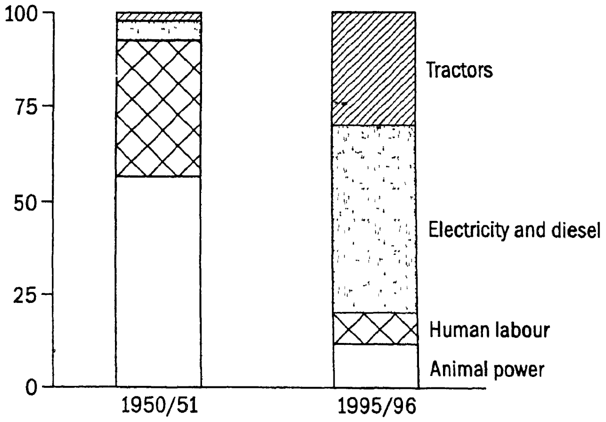


Figure 1 Changes in relative share of different sources of energy in agriculture over time
Source TERI (1988)

Table II Consumption of electricity by agriculture sector (million kWh)

Year	*Agriculture*	*Total*	*Share of agriculture* (%)
1981/82	15 201	90 245	16.84
1985/86	23 422	122 999	19.04
1990/91	50 321	190 357	26.44
1995/96	85 732	277 029	30.95
1997/98[a]	91 277	299 067	30.52

[a] Provisional

Source MoA (1997) and (2000)

sets, 0.25 million power threshers, and 0.4 million plant protection equipment are being manufactured every year. Currently, the total number of tractors in India is estimated to be approximately 1.8 million, enough to cover 17% of the cultivated area. The number of irrigation pump sets has also increased from 1.6 million in 1970/71 to 12.2 million in 1999/2000. Consequently, the electrical energy usage for irrigation has increased from 15 201 GWh in 1981/82 to 91 277 GWh in 1997/98 (Table II).

At this level, around 31% of the total electricity used during 1997/98 was consumed by the agricultural sector. In 1999/2000, the average farm power availability was at 1.15 kW/ha whereas for desired levels of productivity and appropriate post-harvest technologies, a minimum essential estimate is 2.0 kW/ha.

Although farm mechanization has increased over time, the increase in yield levels does not reflect the proper use of energy. The output-to-input ratio (of energy) has declined with time (this can also be due to the distortion of data on energy consumption by irrigation pump sets, as not all energized pump sets are operational). The degradation of natural resources with time has also resulted in an increase in energy usage for the same level of output. With declining groundwater tables across the country, the demand for electricity for irrigation is expected to increase in the future. Thus, there is an urgent need to conserve energy and natural resources, and to improve efficiency of inputs use to achieve sustainable yields in agriculture.

Outlook

Agricultural development in the coming years will face many challenges in view of insufficient capital investment, declining productivity in major cropping systems, and a rapidly shrinking natural resource base. Increased economic growth, population explosion, and shifts in the dietary pattern will change the supply and demand profile of food. Producing more while conserving fast-depleting natural resources and providing physical, economic, and ecological access to food and nutrition security will not be an easy task to accomplish. It is estimated that by 2030, the total foodgrains demand will be 260–264 MT. The domestic demand for rice will be 114 MT and that of wheat 80–83 MT. To meet the rising nutritional needs, demand for pulses, milk, vegetables, fruits, meat, eggs, fish, and sugar will increase with time. Therefore, if the country is to remain self-sufficient, agricultural productivity has to be increased. Since food security is both about maintaining the ecological balance and ensuring economic access to food, future agriculture development strategies should also focus on employment creation and livelihood opportunities to boost income generation.

Therefore, to meet the above-listed challenges, the draft agriculture policy proposes to adopt the following approaches.

- Carry out economic upliftment of the rural poor through the promotion of wage employment, and credit-linked self-employment
- Diversify agriculture to reduce unemployment and under-employment
- Increase income levels of the poor by increasing productivity levels rather than through subsidies and support prices
- Revive investments to help capital formation and rural infrastructure development
- Promote efficient and result-oriented agricultural research and education system
- Develop appropriate post-harvest technologies. Lay due emphasis on development of infrastructure and preservation techniques, storage, and marketing to minimize post-harvest losses
- Develop efficient systems for the transfer of technology to the field, and for the development of human resources to disseminate information. The effective use of electronic

media for agricultural extension and education should also be encouraged.

- Give adequate priority to land reclamation.
- Implement measures to ensure adequate and timely supply of quality inputs such as seeds, fertilizers, and agricultural implements and machinery at reasonable costs and proximity to farmers
- Set agro-processing units in the rural areas to generate employment opportunities
- Create quality consciousness among farmers and agro-processors and introduce grading and standardization to promote export of agriculture products
- Give importance to land, water, and biodiversity conservation through proper natural resources management
- Invest in crop and livestock to enable farmers to cover the risk of instability in production levels and damages caused by natural disasters
- Create a positive trade and investment climate for agriculture on par with industry.

References

MoA. 1997
Agricultural Statistics at a Glance
New Delhi: Ministry of Agriculture, Government of India.

MoA. 2000
Agricultural Statistics at a Glance
New Delhi: Ministry of Agriculture, Government of India.

MoF. 2001
Economic Survey 2000/2001
New Delhi: Ministry of Finance, Government of India.

Planning Commission. 1993
Sectoral energy demand in India
New Delhi: Planning Commission, Government of India.

TERI. 1988
Agricultural energy requirements in India
New Delhi: Tata Energy Research Institute.
[Report No. EM007]

Table 2.01 Contribution (**million rupees**) of agricultural sector to GDP (gross domestic product) and NDP (net domestic product) at current and constant prices: 1990/91 to 1998/99

Prices	*1990/91*	*1991/92*	*1992/93*	*1993/94*[a]	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*
Total GDP									
Current prices	1 351 620	1 592 990	1 779 100	2 218 340	2 551 930	2 778 460	3 340 290	3 527 530	4 286 800
Constant prices	2 420 120	2 392 530	2 522 050	2 620 590	2 760 490	2 751 530	2 994 610	2 950 500	3 143 960
Total NDP									
Current prices	1 272 590	1 498 240	1 669 490	2 109 190	2 431 990	2 644 590	3 191 720	3 365 980	4 111 790
Constant prices	577 730	560 320	597 810	2 109 190	2 221 940	2 193 950	2 425 640	2 368 690	2 556 730

[a] NDP from 1993/94 onwards, the estimates are at 1993/94 prices

Sources

1 CSO. ***National Accounts Statistics*** (various issues). New Delhi: Central Statistical Organization.

2 MoF. 2001. ***Economic Survey*** 2000/01. New Delhi: Ministry of Finance.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (agriculture and national income)]

Table 2.02 Land-use classification (**million hectares**): 1990/91 to 1996/97

Items	*1990/91*	*1991/92*	*1992/93*	*1993/94*[a]	*1994/95*[a]	*1995/96*[a]	*1996/97*[a]
Geographical area	328.73	328.73	328.73	328.73	328.73	328.73	328.73
Reporting area for land utilization	304.86	304.90	304.84	304.88	304.83	304.88	304.88
Forests	67.80	67.87	67.98	68.28	68.60	68.82	68.75
Not available for cultivation	40.48	40.74	40.89	41.00	41.02	41 37	41.54
Area under non-agricultural uses	21.09	21.47	21.87	22.21	22.56	22.36	22.45
Barren and unculturable land	19.39	19.27	19.04	18.69	18.46	19.01	19.09
Other uncultivated land excluding fallow land	30.22	30.05	29.40	29.07	29.02	28.64	28.55
Permanent pastures and other grazing lands	11.40	11.30	11.10	10.97	11.03	11.06	11.04
Land under miscellaneous tree crops and groves, not included in net area sown	3.82	3.76	3.78	3 69	3.73	3.48	3.57
Culturable wasteland	15.00	14.99	14.59	14.41	14.26	14.10	13.94
Fallow lands	23.36	24.60	23 83	24.21	23.22	23.85	23.22
Fallow land other than current fallows	9.66	9 94	9.68	9.83	9 97	10.02	9 89
Current fallows	13.70	14.67	14.15	14.38	13 25	13.83	13 33
Net area sown	143.00	141.60	142.65	142.42	142.96	142 26	142 82
Total cropped area (gross cropped area)	185.74	182 24	185.70	186.60	188.05	187.47	189.54
Area sown more than once	42.74	40.60	42.97	44.18	45.09	44.27	46.72
Cropping intensity (%)[b]	129.89	128.70	130.10	131.00	131.50	131.80	132.70
Net irrigated area	47.78	49.87	50.30	51.34	53.00	53.40	55 14
Gross irrigated area	62.47	65.68	66.76	68.25	70.65	71.35	73.28

[a] provisional

[b] gross cropped area divided by net area sown

Source

Directorate of Economics and Statistics. ***Agricultural Statistics at a Glance*** (various issues). New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (land-related statistics)]

Table 2.03 Area (**million hectares**) under principal crops: 1990/91 to 1999/2000

Crops	*1990/91*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]
Rice	42.7	42.8	42.8	43.4	43.4	44.6	44.6
Wheat	24.2	25.7	25.0	25.9	26.7	27.4	26.7
Pulses	24.7	23.0	22.3	22.4	22.9	23.8	22.3
Foodgrains	127.8	123.7	121.0	123.5	123.8	125.4	123.2
Cotton	7.4	7.9	9.0	9.1	8.9	9.3	8.7
Jute and mesta	1.0	0.9	0.9	1.1	1.1	1.0	1.0
Sugarcane	3.7	3.9	4.1	4.2	3.9	4.1	4.1
Tobacco	0.4	0.4	0	0.4	0.4	0.5	0.5
Oilseeds	24.2	25.3	0.4	26.3	26.1	26.7	25.2
Gross cropped area	185.7	188.1	187.5	189.5	–	–	–

[a] provisional

Source

Directorate of Economics and Statistics. 2000. ***Agricultural Statistics at a Glance.***
New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (area, yield, and production)]

Table 2.04 Production (**million tonnes**) and yield (**kg/ha**) of principal crops: 1990/91 to 1999/2000

	1990/91		*1994/95*		*1995/96*		*1996/97*		*1997/98*		*1998/99*		*1999/2000*[a]	
Crops	*Production*	*Yield*	*Production*	*Yield*	*Production*	*Yield*	*Production*	*Yield*	*Production*	*Yield*	*Production*	*Yield*	*Production*	*Yield*
Rice	74.30	1 740	81.80	1 911	77.00	1 797	81.70	1 882	82.50	1 900	86.0	1 928	88.60	1 985
Wheat	55.10	2 281	65.80	2 559	62.10	2 483	69.40	2 679	66.30	2 485	70.80	2 583	70.10	2 621
Pulses	14.26	578	14.04	610	12.31	552	14.25	635	12.98	567	14.82	622	13.55	608
Foodgrains	176.40	1 380	191.50	1 548	180.40	1 491	199.40	1 614	192.30	1 552	203.40	1 620	201.56	1 637
Cotton[b]	9.84	225	11.90	257	12.90	242	14.23	265	10.90	208	12.20	223	10.45	205
Jute and mesta[c]	9.20	1 634	9.10	1 760	8.80	1 712	11.20	1 818	11.12	1 792	9.70	1 720	9.53	1 779
Sugarcane	241.00	65 395	275.50	71 254	281.10	67 787	277.60	66 496	279.50	71 134	295.70	72 560	292.64	71 989
Tobacco	0.60	1 353	0.60	1 486	0.50	1 356	0.60	1 444	0.60	1 394	0.70	1 522	–	–
Oilseeds	18.60	771	21.30	843	22.10	851	24.40	926	21.30	816	25.20	944	21.54	855

[a] as on 27th March 2000

[b] in bales, 1 bale is 170 kg

[c] in bales, 1 bale is 180 kg

Sources

1 Directorate of Economics and Statistics. 2000. ***Agricultural Statistics at a Glance***. New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

2 MoF. 2000. ***Economic Survey 1999/2000***. New Delhi Ministry of Finance.

Table 2.05 Area (**million hectares**) under high-yielding varieties: 1970/71 to 1997/98

Crops	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1995/96*	*1996/97*[a]	*1997/98*[a]
Paddy							
Area	5.6	18.2	23.5	27.4	31.4	33.40	33.20
Percentage	14.9	45.4	57.1	64.2	–	–	–
Wheat							
Area	6.5	16.1	19.1	21.0	23.1	23.70	23.00
Percentage	35.5	72.3	82.9	86.9	–	–	–
Jowar							
Area	0.8	3.5	6.1	7.1	7.5	8.30	9.00
Percentage	4.6	22.1	38.5	49.4	–	–	–
Bajra							
Area	0.2	3.6	5.0	5.7	5.6	6.10	7.00
Percentage	1.6	30.9	46.7	54.4	–	–	–
Maize							
Area	0.5	1.6	1.8	2.6	3.6	3.80	3.60
Percentage	7.9	26.7	30.6	44.1	–	–	–

[a] anticipated achievement

Sources

1 FAI. 1998. ***Fertilizer Statistics 1997/98***. New Delhi: Fertilizer Association of India.

2 MoF. 1996. ***Economic Survey 1995/96***. p. 137. New Delhi: Ministry of Finance. 296 pp.

3 MoF. 1999. ***Economic Survey 1998/99***. p. 137. S 22. New Delhi: Ministry of Finance.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (area, yield, and production)]

Table 2.06 Progress of India's selected agricultural development programmes (million hectares): 1990/91 to 1997/98

Programme	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*[a]
Area under high-yielding varieties								
Paddy	27.4	28.0	27.5	28.9	31.0	31.4	33.4	32.2
Wheat	21.0	20.5	21.7	22.0	23.2	23.1	23.7	23.0
Maize	2.6	2.8	2.6	2.7	3.4	3.6	3.8	3.6
Jowar	7.1	6.8	6.9	6.8	7.1	7.5	8 3	9.0
Bajra	5.7	5.4	5.6	5.1	5.4	5.5	6.1	7.0
Ragi	1.2	1.2	1.1	1.2	1.2	1.2	1.1	1.2
Total	65.0	64.7	65.4	66.7	71.3	72.3	76.4	76.0
Soil conservation[b]	34.9	35.7	36.5	37.3	38.2[c]	39.3	–	–

[a] provisional

[b] anticipated

[c] cumulative level at the end of the year

Note

For 1992/93 onwards, the figures are cumulative targets for high-yielding varieties, irrigated area, and fertilizer consumption.

Source

MoF. 1999. ***Economic Survey 1998/99***. p. S 22. New Delhi: Ministry of Finance.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (area, yield, and production)]

Table 2.07 Performance of total rainfall in a year

Year	*As percentage of normal rainfall*
1980	104
1985	93
1990	106
1991	91
1992	93
1993	100
1994	110
1995	100
1996	103
1997	102
1998	106
1999	96
2000	92

Source

MoF. 2001. ***Economic Survey 2000/01***. p. 151.
New Delhi: Ministry of Finance.

Table 2.08 Development of irrigation potential (**million hectares**) during Plan periods

Item	*First Plan (1951-56)*	*Fourth Plan (1969-74)*	*Fifth Plan (1974-78)*	*Annual Plans (1978-80)*	*Sixth Plan (1980-85)*	*Seventh Plan (1985-90)*	*At the end of Eighth Plan*	*Ninth Plan target*	*End of 1996/97[a]*	*Anticipated addition (1997/98)*	*At the end of 1998/99[b]*	*At the end of 1999/2000[b]*
Major/medium irrigation												
Potential	12.19	20.71	24.72	26.61	27.70	29.90	33.0	9.81	32.8	1.0	34.7	35.4
Utilization	11.00	18.70	21.20	22.70	23.63	25.50	28.4	8.71	28.4	0.9	30.1	30.5
Minor irrigation												
Potential	14.06	23.50	27.30	30.00	37.52	46.60	56.6	7.24	56.5	0.8	58.1	59.4
Utilization	14.06	23.50	27.30	30.00	35.25	43.12	52.3	4.93	52.3	1.4	53.5	54.2
Total irrigation												
Potential	26.25	44.21	52.02	56.61	65.20	76.50	89.6	17.05	89.3	1.8	92.8	94.7
Utilization	25.06	42.20	48.50	52.70	58.80	68.60	80.8	13.64	80.7	2.3	83.7	84.7

[a] anticipated achievement

[b] provisional

Sources

1 ***Eighth Five-Year Plan: 1992-97***. Volume II. p. 57. New Delhi: Planning Commission, Government of India. 480 pp.

2 MoF. ***Economic Survey*** (various issues) New Delhi: Ministry of Finance

For more details, please see TEDDY ONLINE+ [Section: agriculture (outlay and expenditure)]

Table 2.09 Irrigated area (**million hectares**) under selected crops: 1990/91 to 1996/97

Crops	*1990/91*	*1991/92*	*1992/93*[a]	*1993/94*[a]	*1994/95*[a]	*1995/96*[a]	*1996/97*[a]
Rice	19.4	20.2	20.1	20.7	21.4	21.5	22.20
Total rice area (%)	45.5	47.3	48.0	48.6	49.8	49.9	51.00
Jowar	0.8	0.8	0.8	0.8	0.8	0.8	0.80
Total jowar area (%)	5.6	6.5	6.1	6.2	6.7	6.8	6.70
Bajra	0.5	0.7	0.6	0.7	0.6	0.6	0.50
Total bajra area (%)	5.1	6.5	5.8	6.6	5.8	6.2	5.30
Maize	1.2	1.3	1.3	1.4	1.3	1.4	1.30
Total maize area (%)	19.7	22.5	21.5	22.6	21.3	22.6	20.60
Wheat	19.5	19.6	20.8	21.4	22.0	21.6	22.40
Total wheat area (%)	81.1	83.7	84.2	85.1	84.9	85.8	86.20
Barley	0.5	0.6	0.6	0.5	0.6	0.5	0.50
Total barley area (%)	54.5	60.7	60.8	58.1	66.7	60.3	62.90
Cereals	42 3	43.4	44.4	45.6	46.8	46.5	47.90
Total cereals area (%)	41.0	43.4	43.7	45.0	46.1	46.6	47.00
Pulses	2.6	2.4	2.5	2.6	3.1	3.0	3.00
Total pulses area (%)	10.5	10.7	10.5	11.2	12.8	12.9	12.70
Foodgrains	44.9	45.8	46.9	48.2	49.9	49.5	50.80
Total foodgrains area (%)	35.1	37.4	37.4	38.7	39.6	40.1	40.60
Oilseeds	5.8	6.8	6.4	6.5	6.8	7.3	7.40
Total oilseed area (%)	22.9	25.5	24.1	23.0	25.0	26.0	26.30
Cotton	2.5	2.6	2.7	2.6	2.7	3.2	3.30
Total cotton area (%)	32.9	33.3	34.6	34.3	33.8	35.0	35.80
Sugarcane	3.4	3.6	3.5	3.4	3.6	3 9	3.90
Total sugarcane area (%)	86.9	88.0	88.3	89.0	83.7	87.4	88 10

[a] provisional

Note

Irrigated area under oilseeds denotes the area under groundnut, rapeseed, mustard, linseed, sesame, and others.

Sources

1 Directorate of Economics and Statistics. 1998. ***Agricultural Statistics at a Glance***. New Delhi: Department of Agriculture and Cooperation, Ministry of Agriculture.

2 MoF. 2000. ***Economic Survey 2000/01***. S-23. New Delhi: Ministry of Finance.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (irrigation-related statistics)]

Table 2.10 Irrigated area (**million hectares**) by various sources: 1990/91 to 1995/96

Source of irrigation	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*
Government canals	16.50	16.81	16.50	16.50	16.80	16.58
Private canals	0.51	0.49	0.48	0.48	0.48	0.56
Tanks	3.32	3.32	3.18	3.17	3.28	3.11
Tube wells	14.26	15.17	15.82	16.38	17.19	17.94
Other wells	10.09	10.87	11.11	11.39	11.72	11.86
Other sources	3.11	3.20	3.21	3.43	3.53	3.46
Total net irrigated area	47.79	49.87	50.30	51.34	53.00	53.51

Note
Due to rounding off, the total may not tally exactly.

Source
FAI. 1999. ***Fertilizer Statistics 1998/99***. New Delhi: Fertilizer Association of India.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (irrigation-related statistics)]

Table 2.11 Consumption (**million tonnes**) of nitrogenous, phosphatic, and potassic fertilizers: 1991/92 to 2000/01

Fertilizer	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*[a]	*1999/2000*[a]	*2000/01*[a]
Nitrogenous	8.0	8.4	8.8	9.5	9.8	10.3	10.9	11.3	11.6	12.3
Phosphatic	3.3	2.8	2.7	2.9	2.9	3.0	3.9	4.1	4.8	5.1
Potassic	1.4	0.9	0.9	1.1	1.2	1.0	1.4	1.4	1.7	1.9
Total	12.7	12.1	12.4	13.5	13.9	14.3	16.2	16.8	18.1	19.4

[a] provisional

Sources
1 FAI 1997. ***Fertilizer Statistics 1996/97***. New Delhi. Fertilizer Association of India.
2 MoF. 2001. ***Economic Survey 2000/01***. New Delhi: Ministry of Finance.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (fertilizer, pesticide, and other inputs)]

Table 2.12 Production and consumption (**tonnes**) of technical-grade pesticides: 1989/90 to 1995/96

Production / Consumption	*1989/90*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*[a]
Production	66 470	–	75 000	77 000	–	–	–
Consumption	72 000	75 000	72 130	70 790	63 650	61 360	56 110

[a] anticipated achievement

Sources
1 Kothari Publications. 1993. ***Indian Agriculture in Brief***. Kothari's Deskbook Series. The Pesticides Industry. p. 19. Chennai: Kothari Publications.
2 Directorate of Economics and Statistics. 1998. ***Agricultural Statistics at a Glance***. New Delhi: Department of Agriculture and Cooperation, Ministry of Agriculture.

Table 2.13 Consumption of pesticides (**tonnes**): 1985/86 to 1994/95

State / Union Territory	*1985/86*	*1986/87*	*1987/88*	*1994/95*	*Share* (%)
State					
Andhra Pradesh	14 400	9136	8860	13 000	16.11
Arunachal Pradesh	17	18	25	42	0.05
Assam	810	1410	531	630	0.78
Bihar	1750	2000	3000	2600	3.22
Goa	56	55	11	12	0.01
Gujarat	4500	2090	2080	5100	6.32
Haryana	3608	3995	3700	5250	6.51
Himachal Pradesh	690	553	545	290	0.36
Jammu and Kashmir	748	92	85	142	0.18
Karnataka	3280	3265	4500	4400	5.45
Kerala	1130	1039	1059	700	0.87
Madhya Pradesh	3400	4000	3000	2757	3.42
Maharashtra	3089	6070	6090	6900	8.55
Manipur	43	40	38	42	0.05
Meghalaya	40	42	44	19	0.02
Mizoram	6	7	10	13	0.02
Nagaland	9	4	13	–	–
Orissa	1200	1400	1700	1700	2.11
Punjab	4620	5800	4860	6450	7.99
Rajasthan	2444	3240	2970	3900	4.83
Sikkim	16	18	20	32	0.04
Tamil Nadu	10 000	11 000	11 600	9500	11.77
Tripura	190	160	138	100	0.12
Uttar Pradesh	6010	6550	6920	11 000	13.63
West Bengal	5000	5100	4900	5823	7.22
Union Territory					
Andaman and Nicobar Islands	7	4	4	19	0.02
Chandigarh	3	4	3	2	0
Dadra and Nagar Haveli	3	4	4	6	0.01
Daman and Diu	0	1	1	1	0
Delhi	40	46	50	75	0.09
Lakshadweep	4	1	1	2	0
Pondicherry	106	128	134	152	0.19

Source

CMIE. 1996. ***India's Agricultural Sector***. Mumbai: Centre for Monitoring Indian Economy.

Table 2.14 Progress of farm mechanization: 1970 to 1993

Items	*1970*	*1974*	*1980*	*1985*	*1988*	*1993*
Gross cropped area (million hectares)	165.8	170.0	169.7	176.0	177.0	183.0
Tractors						
Cumulative total (million)	0.10	0.23	0.47	0.82	1.05	1.80
Per million hectare of gross cropped area	610	1320	2790	4660	5950	9860
Oil engines						
Cumulative total (million)	–	1.75	2.65	3.35	4250.00	5.20
Per million hectare of gross cropped area	–	10 320	15 640	19 690	24 000	28 490
Irrigation pumps, electricity-operated tube wells						
Cumulative total (million)	1.35	2.43	3.97	5.71	7.00	9.62
Per million hectare of gross cropped area	8340	14 280	23 360	32 360	39 950	52 710
Consumption of power (kWh) for irrigation per thousand hectare of gross cropped area	23.30	37.40	79.50	116.10	196.70	350.70

Sources

1 TERI. 1995. **ECOMILES (Environmental Considerations and Options in Managing India's Long-term Energy Strategy).** p. 59. New Delhi: Tata Energy Research Institute. 241 pp.

2 MoPNG. 1998. ***Basic Statistics on Indian Petroleum and Natural** Gas*. p. 33. New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (mechanization)]

Table 2.15 Contribution of various energy sources to farm power: 1991/92

Sources of farm power	*Number* (million)	*Total* (GW)	*Total* (%)
Human			
Male	149.20	8.95	7.32
Female	50.80	2.54	2.08
Draught animals	84.00	31.50	25.76
Tractors	1.30	29.10	23.80
Power tillers	0.09	0.54	0.44
Diesel engines	4.60	17.16	14.04
Electric motors	8.30	30.96	25.32
Combines	0.04	1.51	1.24

Source

TERI. 1995. **ECOMILES (Environmental Considerations and Options in Managing India's Long-term Energy Strategy).** p. 59. New Delhi: Tata Energy Research Institute. 241 pp.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (mechanization)]

Table 2.16 Changes in various energy sources (**number**): 1971/72 to 1991/92

State	*1971/72*[a]			*1981/82*				*1991/92*			
	Working bovine[b]	*Tractor*[c]	*Pump (electric/ diesel)*	*Working bovine*	*Tractor*	*Power tiller*[c]	*Pump (electric/ diesel)*	*Working bovine*	*Tractor*	*Power tiller*	*Pump (electric/ diesel)*
Andhra Pradesh	66	1	2	55	27	2	9	63	48	1	16
Assam	141	–	–	138	–	–	–	157	–	23	1
Bihar	90	4	1	94	25	1	5	115	59	25	10
Gujarat	36	3	4	44	39	5	10	34	103	–	12
Haryana	31	32	3	38	216	41	11	22	387	317	17
Karnataka	44	–	2	44	18	10	5	42	50	11	7
Kerala	42	9	5	16	13	13	12	9	3	15	32
Madhya Pradesh	59	–	–	62	16	3	3	67	73	12	6
Maharashtra	40	15	2	41	12	–	7	38	34	2	10
Orissa	115	–	–	102	6	–	–	122	5	2	2
Punjab	47	107	8	34	399	478	23	20	1,024	584	42
Rajasthan	26	4	1	25	20	7	4	17	91	10	9
Tamil Nadu	95	7	8	72	11	4	20	53	66	18	32
Uttar Pradesh	103	12	3	84	70	24	8	63	215	58	16
West Bengal	125	–	2	123	3	–	10	115	37	86	13
India (average)	68	7	3	62	41	21	7	59	109	41	12

[a] in 1971/72, there were no power tillers

[b] working bovine per 100 ha of operated area

[c] per 10 000 ha of operated area

Source

NSSO. 1997. ***Land and livestock holding survey. NSS 48th round 1992.*** New Delhi: National Sample Survey Organization, Department of Statistics, Government of India.

Table 2.17 Number of pump sets energized: March 1995 to March 1999

	Number of pump sets energized				
State / Union Territory	*Cumulative (March 1995)*	*Cumulative (March 1996)*	*Cumulative (March 1997)*	*Cumulative (March 1998)*	*Cumulative (March 1999)*
State					
Andhra Pradesh	1 605 807	1 642 993	1 821 291	1 824 689	1 884 571
Assam	–	3 675	3 675	3 675	3 675
Bihar	264 755	267371	269 345	270 277	271 090
Goa	5 441	5 732	6 063	6 454	6 590
Gujarat	551 551	568 858	591 564	617 495	643 757
Haryana	404 107	406 612	408 461	409 404	410 224
Himachal Pradesh	4 141	4 441	4 780	5 098	5 392
Jammu and Kashmir	3 586	4 716	5 088	5 621	5 621
Karnataka	973 288	1 014 918	1 049 465	1 082 150	1 141 824
Kerala	289 866	304 904	314 632	329 355	353 405
Madhya Pradesh	1 087 404	1 131 435	1 176 317	1 229 016	1 274 873
Maharashtra	1 883 152	2 025 973	2 091 718	2 151 191	2 208 738
Manipur	45	45	45	45	45
Meghalaya	65	65	65	65	65
Mizoram	–	–	–	–	–
Nagaland	176	176	176	176	176
Orissa	65 145	69 184	70 144	72 047	73 359
Punjab	681 432	709 916	726 221	735 162	744 972
Rajasthan	488 770	514 758	539 762	565 068	590 119
Sikkim	–	–	–	–	–
Tamil Nadu	1 487 654	1 528 807	1 567 322	1 609 242	1 643 915
Tripura	1 738	1 764	1 764	1 764	1 764
Uttar Pradesh	727 937	761 272	778 512	790 157	806 270
West Bengal	98 329	101 232	102 773	104 383	107 238
Total	10 585 006	11 068 847	11 529 183	11 812 534	12 177 683
Union Territory					
Total	34 578	35 243	36 159	36 872	37 453
Grand total	10 619 584	11 104 090	11 565 342	11 849 406	12 215 136

Source

Planning Commission. 2000. ***Annual Report on the Working of State Electricity Boards and Electricity Departments.*** p. 83. New Delhi: Power and Energy Division, Planning Commission, Government of India.

Table 2.18 Procurement/support prices (**rupees per tonne**) of foodgrains / commercial crops: 1990/91 to 2000/01

Foodgrains / Commercial crops	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*	*2000/01*
Paddy	2 050	2 300	2 700	3 100	3 400	3 600	3 800	4 150	4 400	4 900	5 100
Maize	1 800	2 100	2 450	2 650	2 900	3 100	3 200	3 600	3 900	4 150	4 450
Wheat	2 250	2 500	3 300	3 500	3 500	3 600	3 800	4 775	5 100	5 500	5 800
Gram	4 500	5 000	6 000	6 400	6 700	7 000	7 400	8 150	8 950	10 000	10 150
Sugarcane	220	260	310	345	391	425	459	485	527	561	–
Cotton	6 200	6 500	8 000	9 000	10 000	11 500	11 800	13 300	14 400	15 750	16 250
Jute	3 200	3 750	4 000	4 500	4 700	4 900	5 100	5 700	6 500	7 500	7 850
Groundnut	5 800	6 450	7 500	8 000	8 600	9 000	9 200	9 800	10 400	11 550	12 200
Soyabean (black)	3 500	3 950	4 750	5 250	5 700	6 000	6 200	6 700	7 050	7 550	7 750
Mustard	6 000	6 700	7 600	8 100	8 100	8 300	8 600	8 900	9 400	10 000	11 000
Tobacco (Rs/quintal)	13 250	14 750	16 000	18 000	18 500	19 000	19 000	20 500	22 500	25 000	–

Note

Prices are announced by the Government of India

Sources

1 Directorate of Economics and Statistics. 1999. ***Agricultural Statistics at a Glance***. New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

2 MoF. ***Economic Survey*** (various issues). New Delhi: Ministry of Finance.

For more details, please see TEDDY ONLINE+ [Section: Agriculture (prices)]

Table 2.19 Public sector plan outlays (**million rupees**) on the agriculture sector during different five-year plans and annual plans

Agriculture development	*Fourth Plan (1969-74)*	*Fifth Plan (1974-78)*	*Sixth Plan (1980-85)*	*Seventh Plan (1985-90)*	*Eighth Plan (1992-97)*	*Annual Plan*						
						1992/93	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*
Agriculture and allied activities	27 280	46 440	56 950	105 740	224 670	47 100	54 090	58 460	66 610	69 257	69 740	86 871
Agricultural research and education	–	–	5 380	7 050	20 180	3 360	4 010	4 520	5 090	5 213	5 745	8 190
Crop husbandry	5 050	13 220	12 340	33 120	92 750	15 600	18 120	19 710	20 040	21 553	20 593	26 553
Soil and water conservation	1 590	2 210	4 340	7 400	23 050	3 540	4 330	4 300	5 130	5 812	5 659	8 247
Animal husbandry and dairying	2 330	4 380	8 510	10 770	28 380	4 410	6 270	6 330	7 160	6 639	5 920	6 277
Fisheries	830	1 500	3 710	4 990	12 320	2 170	2 610	2 730	3 120	3 077	3 412	3 968
Forestry and wildlife	930	2 060	6 930	18 590	–	8 130	9 100	10 270	10 970	12 176	13 336	18 319
Management of natural deserts	–	–	150	210	–	–	–	–	–	–	–	–
Agricultural marketing and rural godowns	940	–	960	1 490	–	–	–	–	–	–	–	–
Food, storage, warehousing, and food processing	190	1 240	3 380	3 070	5 440	950	830	740	860	1 104	1 224	1 083
Investment in agricultural financial institutes	3 240	5 190	8 210	3 540	5 210	1 700	1 530	2 550	5 510	4 487	4 895	4 987
Cooperatives	1 790	3 760	–	14 010	30 570	–	–	–	–	–	–	6 349
Plantation	–	–	–	1 500	2 070	740	880	880	1 010	1 031	2 055	1 682
Land reforms	–	1 630	3 050	–	10 870	1 570	1 890	1 970	2 370	2 857	2 006	3 405
Other agricultural programmes	–	1 270	–	–	4 690	810	740	770	630	1 196	1 175	1 218
Irrigation and flood control	25 830	42 330	121 600	169 790	325 250	49 350	58 540	64 950	74 730	97 600	112 204	13 443
Major and medium irrigation	12 370	30 950	84 480	115 560	224 150	31 280	38 410	42 850	50 460	70 813	–	–
Minor irrigation	11 740	7 920	18 100	28 050	59 770	10 880	12 160	14 130	15 200	17 164	–	–
Command area development	–	–	8 560	16 710	25 100	3 580	4 570	4 760	5 360	4 309	–	–
Flood control including anti-sea erosion	1 720	3 460	10 450	9 470	16 230	3 600	3 400	3 210	3 710	53 014	–	–

Sources

1 Planning Commission. *Annual Plan* (various issues). New Delhi: Planning Commission, Government of India.

2 Planning Commission. *Five-Year Plan* (various issues). New Delhi: Planning Commission, Government of India

3 Directorate of Economics and Statistics. ***2000. Agricultural Statistics at a Glance 2000.*** New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture

For more details, please see TEDDY ONLINE+ [Section: Agriculture (outlay and expenditure)]

Table 2.20 Agricultural perspective: 1984/85 to 2006/07

Variable	*1984/85*	*1991/92*^{a}	*1996/97*	*2001/02*	*2006/07*
Land (million hectares)					
Net sown area	140.9	140.0	142.0	142.0	142.0
Gross growth area	176.4	182.2	190.6	197.2	203.4
Gross cropped area foodgrains	126.7	127.0	130.0	132.6	135.0
Irrigation (million hectares)					
Foodgrains	44.2	53.8	62.3	70.2	77.7
Non-foodgrains	16.3	21.9	27.0	31.8	36.3
Total	60.5	75.7	89.3	102.0	114.0
Fertilizer (million tonnes)					
Foodgrains	6.2	9.4	12.8	16.6	21.0
Non-foodgrains	2.1	4.1	5.5	7 1	9.0
Total	8.2	13.5	18.3	23.7	30 0
Cotton (million bales)	8.5	10.5	14.0	18.0	23.0
Sugarcane (million tonnes)	170.3	235.0	275.0	335.0	408.0
Foodgrains (million tonnes)	145.5	172.5	210.0	245.0	285.0
Oilseeds (million tonnes)	13.0	17.5	23.0	29.0	37.0

^{a} likely assured base level

Source

Directorate of Economics and Statistics. 2000. ***Agricultural Statistics at a Glance.*** New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

Table 2.21 India's livestock population: 1977 to 1992

	Number of animals			
Animals	*1977*	*1982*	*1987*	*1992*
Cattle	180 140	192 453	199 695	204 584
Buffaloes	62 019	69 783	75 967	84 206
Sheep	40 907	48 765	45 703	50 783
Goats	75 620	95 255	110 207	115 279
Horses and ponies	916	900	797	817
Pigs	7 647	10 071	10 626	12 788
Mules	89	131	167	193
Donkeys	978	1 024	958	967
Camels	1 068	1 078	1 001	1 031
Other livestock				
Yaks	132	128	36	58
Mithuns	129	154	129	154
Total	369 645	419 742	445 286	470 860

Source

Directorate of Economics and Statistics. 2000. ***Agricultural Statistics at a Glance.*** New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

Table 2.22 All-India pattern of outlay expenditure (**million rupees**) in public sector by plan

	Agriculture and allied activities		*Total*		*Percentage of agriculture and allied activities to total*	
Plan period	*Plan outlay*	*Actual expenditure*	*Plan outlay*	*Actual expenditure*	*Plan outlay*	*Actual expenditure*
First Plan (1951-56)	3 540	2 900	23 780	19 600	14.90	14.80
Second Plan (1956-61)	5 100	5 490	45 000	46 720	11.30	11.80
Third Plan (1961-66)	10 860	10 890	75 000	85 770	14.50	12.70
Annual Plans (1966-69)	10 370	11 070	66 650	66 250	15.60	16.70
Fourth Plan (1969-74)	27 280	23 200	159 020	157 790	17.20	14.70
Fifth Plan (1974-79)	47 660	48 650	393 220	394 260	12.10	12.30
Annual Plan (1979-80)	18 150	19 960	126 010	121 760	14.40	16.40
Sixth Plan (1980-85)	125 390	152 010	975 000	1 092 920	12.90	13.90
Seventh Plan (1985-90)	222 330	315 090	1 800 000	2 187 300	12.40	14.40
Annual Plan (1990/91)	91 420	85 420	647 170	583 690	14.10	14.60
Annual Plan (1991/92)	100 580	90 600	723 170	64 750	13.90	13.90
Eighth Plan (1992/97)	636 420	–	4 341 000	–	14.70	14.70
Annual Plan (1992/93)	104 260	105 370	807 720	728 520	12.90	14.50
Annual Plan (1993/94)	130 020	126 600	1 001 200	880 810	13.00	14.40
Annual Plan (1994/95)	160 210	154 960	1 121 970	981 670	14.30	15.80
Annual Plan (1995/96)	183 630	154 570	1 285 900	1 073 800	14.30	13.44
Annual Plan (1996/97)	197 930	159 970	1 461 070	1 189 764	13.50	12.80
Ninth Plan (1997-2002)	115 390	–	8 750 000	–	13.20	–
Annual Plan (1997/98)	189 110[b]	172 241[a]	1 559 050	1 362 590	12.10	12.33
Annual Plan (1998/99)	216 710[b]	191 408[a]	1 859 075[b]	1 585 984[a]	11.65	12.06
Annual Plan (1999/2000)	91 439	–	1 035 210	–	–	–

[a] revised estimate

[b] budget estimate

Source

Directorate of Economics and Statistics. 2000. ***Agricultural Statistics at a Glance.*** New Delhi: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

TATA
Relationship. The bond for building quality.

Relationship forms the building blocks of quality. More than technology, more than processes, it's our concern for you that spurs us to create quality A quality based on empathy and lasting ties.

Visit us at www tatasteel.com

TATA STEEL

Industry

At a glance

- The Indian industrial sector consumes (as fuel and feedstock) about half of the country's total commercial energy production. Coal and lignite meet over half of the industrial commercial energy requirements.
- A few energy-intensive industries consume over 80% of industrial energy, including fertilizers, aluminium, textiles, cement, iron and steel, pulp and paper, and chlor-alkali.
- The iron and steel sector is the largest consumer of energy in the industrial sector. Energy accounts for 30%–35% of the costs of production of iron and steel, 70% of it being used in making iron in the blast furnace. Coking and non-coking coal, liquid hydrocarbons, and electricity are used for the purpose.
- India is the world's third largest producer of nitrogenous fertilizers. The production process of ammonia is highly energy-intensive, using large amounts of petroleum-based fuels.
- Energy accounts for nearly 40% of aluminium production costs. While electricity constitutes 80% of total energy-use, coal and fuel oil are also used.
- In textiles, India's single largest organized industry, energy in the form of coal, electricity, and furnace oil accounts for an estimated 12%–15% of the total cost of production. Energy-saving potential is estimated to be as high as 23%.
- India is the world's third largest producer of cement. Coal is the main source of energy for cement production. While most of the new and large units compare well with the world's most energy-efficient plants, an estimated 10% savings is possible in the older units.
- Energy costs constitute 30% of total manufacturing costs in pulp and paper. Larger mills that have chemical recovery systems and cogeneration are more energy-efficient than the smaller mills.
- In the chlor-alkali industry, energy accounts for 50%–60% of total production costs and the energy-saving potential is estimated at 15% of total energy used.

Introduction

The economic reforms initiated by the Government of India in the 1990s have led to a critical phase of transition and restructuring of the Indian industry. A number of policy initiatives were undertaken during the Eighth Five-year Plan. Industrial policy reforms were carried forward in the Union Budget (1999/2000). To consolidate the recovery in industrial growth during 1999/2000 and to push through the industrial policy reforms further, major policy initiatives were announced in Budget 2000/01. A list of these initiatives is given below.

1. The rationalization of excise duty by introducing CENVAT (central value-added tax) and reducing the number of rates of excise duty.
2. The extension of the maximum retail price based excise duty to more items, which will lead to the simplification of the excise procedure.
3. A raise in the limit for providing collateral to obtain finance from 0.1 million to 0.5 million rupees for SSI (small-scale industry) units in the tiny sector.
4. A reduction in customs duty on several items of the IT (information technology) and telecommunications sectors.
5. An enhancement of the corpus of RIDF (Rural Infrastructure Development Fund) VI and a reduction of the interest charged on this by 0.5%.
6. MODVAT (modified value-added tax) credit of CVD (countervailing duties) paid on project imports allowed up to 100%.
7. Permission to raise FII (foreign institutional investment) equity limit to 40% through a special resolution by shareholders.

The Budget also announced a number of fiscal incentives and other measures to strengthen the capital markets and the banking system. The benefit for the infrastructure sector has been extended to essential sectors of urban infrastructure, viz. water treatment and solid waste management. In pursuance of the government's commitment to facilitate industrial growth through foreign participation, FDI (foreign direct investment) has been permitted through the automatic route for all industries except a small negative list. In the process of review of laws, regulations, and simplification of procedures, an expert group constituted by the government has finalized its recommendations. The group has proposed enactment of a new industry act, which would focus on the promotion and development of industry instead of its regulation. The government has initiated the process of examining the feasibility of framing a new enactment in this regard.

The general IIP (index of industrial production) recorded a growth rate of 6.6% in 1999/2000 (at 1993/94 prices) as compared with 4.1% in 1998/99. This was due to the better performance of the manufacturing sector which recorded a higher growth rate of 7.1%; the mining and electricity sectors recorded growth rates of 1.0% and 6.6%, respectively in 1999/2000.[1] This growth rate is much lower than the 12.8% growth achieved in 1995/96 (Figure 1).

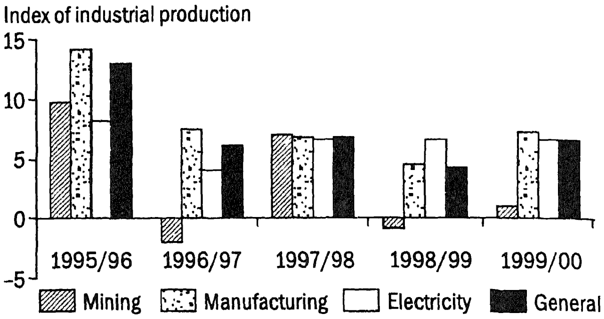


Figure 1 Annual growth rates (%) in major sectors of industry (Base: 1993/94 = 100)

After a turnaround in 1999/2000, industrial growth has again slowed down during 2000/01 (April–December). The overall industrial growth during April–December of 5.7% is lower than 6.4% during the corresponding period in 1998/99. The factors responsible for the slowdown of industrial growth during the year include a lack of domestic demand for intermediate goods; a low inventory demand for capital goods; high oil prices, existence of excess capacity in some sectors; business cycle; inherent adjustment lags in industrial restructuring and infrastructure constraints, particularly power, roads and transport; as well as a high interest rate environment because of a high fiscal deficit.

The industrial sector consumes about 50% (including feedstock) of the total commercial energy produced in the country. The total industrial energy consumption, including non-energy uses, grew from 45.7 MTOE (million tonnes of oil equivalent) in 1984/85 to 113.1 MTOE in 1996/97. Of the commercial sources of energy, coal and lignite contribute about 57%, oil and natural gas 33%, hydroelectric power 3%, and nuclear power 0.2%. The relative shares of different types of fuels consumed in the industry are given in Table 2.23.

---

[1] The manufacturing sector has a weight of 79.36% in IIP, followed by mining (10.47%) and electricity (10.17%).

This chapter focuses on seven energy-intensive industries, namely fertilizer, aluminium, iron and steel, textiles, cement, chemicals, and pulp and paper. These industries account for nearly 80% of the total industrial energy consumption, and there is tremendous scope for improving energy efficiency.

Fertilizer

There are mainly four types of fertilizers: nitrogenous, phosphatic, potassic, and complex. Phosphatic fertilizers play an insignificant part in the domestic production of fertilizers, and no potassic fertilizers are produced in India. India operates around 55 nitrogenous fertilizer plants and ranks third in the world in terms of production.

The capacity utilization of the nitrogenous fertilizer plants increased from 91.0% in 1994/95 to 98.2% in 1999/2000 (Table 2.24). This was due to the higher capacity utilization of the majority of the new gas-based plants and the improved performance of some of the older plants based on naphtha/fuel oil. The shares of capacity of nitrogenous fertilizer plants in 1999/2000 among the public, cooperative, and private sectors were 37%, 20%, and 43%, respectively. The imports of fertilizers from 1994/95 to 1999/2000 are shown in Table 2.25.

The fertilizer industry, particularly nitrogenous fertilizers, is highly energy-intensive. The fertilizer industry is also one of the largest consumers of petroleum-based fuels. The consumption of these fuels has increased from 4.384 million tonnes in 1993/94 to 6.717 million tonnes in 1998/99 (Table 2.26).

The energy consumed in the production of ammonia has a great impact on the overall energy consumption of the fertilizer industry. Production of ammonia accounts for more than 80% of the total energy consumed in the manufacture of finished fertilizer products. The specific energy consumption for ammonia production is shown in Table 2.27. During the last four decades, the Indian fertilizer industry saw many changes in feedstock, technology, etc., that resulted in substantial improvement in the efficiency of overall energy-use.

The shares of major feedstock in nitrogenous fertilizer capacity during 1999/2000 were natural gas 45.4%, naphtha 29.9%, and fuel oil 10.3%. In terms of calorific content, natural gas is the largest source of energy in the fertilizer industry. Because of the higher energy efficiency of gas-based fertilizer plants and because natural gas is a cleaner fuel and easy to handle, natural gas still remains the most preferred feedstock for setting up new fertilizer plants. However, due to the unavailability of sufficient indigenous natural gas for fertilizer production, new investments are being planned using naphtha as feedstock. This is also because fertilizer plants, based on fuel oil and low-sulphur heavy stock, have high levels of energy consumption and are very polluting. If imported natural gas can be made available in the country at competitive prices, future capacity addition will come in the form of gas-based plants. In such a scenario, where natural gas is plenty, depending on the pricing of natural gas in the deregulated markets, it might be feasible to adapt some fertilizer plants to the use of natural gas for feedstock and fuel.

As to technology supply, recent advances in process technology and catalysts have also resulted in lower energy intensity in the fertilizer production. The energy conservation schemes for ammonia plants include reformer tubes of superior material, adiabatic pre-reformer, low steam: carbon ratio, purge gas recovery unit, make-up gas chiller at suction, synthesis converter revamp, and computer control and optimization. For urea plants, the energy conservation schemes include the installation of the urea hydrolizer stripper, trays inside the reactor, a coil to feed the reactants from the top of the reactor, an internal heat recovery system, and a vacuum preconcentrator.

In addition to these technical measures, policy issues have a profound impact on the performance of this sector from the point of view of energy and the environment. The NIP (National Industrial Policy), unveiled in July 1991, announced the delicensing of the fertilizer industry. Promoters are now free to set up fertilizer plants in the country without obtaining a licence from the government, provided they obtain an environmental clearance.

Some of the recommendations of the high-powered Fertilizer Pricing Policy Review Committee are listed below.

- Deregulate the fertilizer industry; allow units to fix their retail pricing subject to ceiling farm prices
- Encourage the restructuring of plants based on naphtha, fuel oil, and coal to move over to more energy-efficient feedstock

- Promote the balanced use of fertilizers by setting appropriate relative prices for fertilizers
- In the light of the current relative pricing of different feedstocks, base future fertilizer production on domestic natural gas and LNG (liquefied natural gas).

Aluminium

The aluminium industry in India has made much progress since it was set up in the 1930s. The installed capacity has increased from 4000 tonnes in 1950 to 714 000 tonnes in 1998/99. At present, one public sector company and four in the private sector produce aluminium. They are (1) Bharat Aluminium Company Ltd, Korba, Madhya Pradesh; (2) Indian Aluminium Company Ltd, Belgaum in Karnataka, Hirakud in Orissa, and Alwaye in Kerala; (3) Hindalco Industries Ltd, Renukoot, Uttar Pradesh; (4) Madras Aluminium Company Ltd, Mettur, Tamil Nadu; and (5) National Aluminium Company Ltd, Angul, Orissa. Table 2.29 gives the installed capacity, production, and capacity utilization of each plant.

Bauxite is the basic raw material used in the production of aluminium. India possesses nearly 8.3% (2650 million tonnes) of the total known reserves of bauxite in the world (32 000 million tonnes). The BHH (Bayer–Hall–Heroult) process has remained practically the only viable commercial manufacturing process since the discovery of aluminium in 1886.

Aluminium production is a highly energy-intensive process, with energy accounting for nearly 40% of the production cost. Considerable R&D efforts are being made to improve the BHH technology and also to find an alternative process. Several organizations are experimenting with new production processes, which they claim have significant advantages over the BHH process. However, these processes are either at the laboratory stage or under pilot operation.

The consumption of aluminium grew by nearly 5% annually during the Eighth Plan. This was mainly due to the slowdown of the economy, resource constraints faced by the state electricity boards, and lower investment in aluminium-consuming sectors because of a liquidity crunch in the economy. However, the Ninth Plan achieved an 8% growth in demand for aluminium and an increase in installed capacity from 670 000 tonnes a year to 714 000 tonnes a year.

The two major energy-consuming steps in the production process are the conversion of bauxite ore to alumina and the production of aluminium from alumina. About 2.5 tonnes of bauxite are required to produce 1 tonne of alumina and about 2 tonnes of alumina for 1 tonne of aluminium. Tables 2.31 and 2.32 show the specific energy consumption and performance parameters of aluminium plants in India. Fuel oil is used for firing calcining kilns. Besides calcination, some units also use fuel oil to generate steam required for digestion and evaporation. Coal is used only for steam generation whereas electricity is largely used in the smelting and grinding of bauxite.

Electricity, coal, and fuel oil are the major forms of energy used by the aluminium sector, with electricity accounting for 80% of the total energy use.

Electrical power is utilized in smelters for aluminium production. Some of the energy-saving options identified in smelters are given below.

- Provision for mechanized and automatic alumina feeding facilities
- Automation and mechanization of cell operation by introducing microprocessors and computers
- Improvement in cathode lining and cell design
- Improvement in anode design, exploring the possibility of increasing anode areas by redesigning the existing cell
- Provision for efficient gas cleaning and recovery of fluorides by dry scrubbing system

With a coordinated approach on all fronts, energy saving in the range of 15%–20% of the total energy-use may be achieved.

Although Indian companies have taken measures in recent years to reduce specific power consumption, it is still significantly higher than the international norms. Considerable R&D efforts are being made to improve the BHH technology, and also to find an alternative process route, less energy-intensive and less costly, for aluminium production (TERI 1996). Some of the promising processes include Carbothermic, Toth, and Kuwahara.

Textile

The textile industry is the single largest organized industry in India, accounting for about four per cent of the GDP (gross domestic product) and one-fifth of the total industrial output (TERI 1996). It accounts for around one-third of the total export earnings and provides employment to over 20 million people. It is essential for the textile industry to have access to timely and adequate capital at internationally comparable rates of interest in order to upgrade its technology level. It had been felt necessary to make operational a focused and time-bound TUF (technology upgradation fund) scheme, which would provide a modal point for modernization efforts through technology upgradation in the industry. The main feature of the TUF scheme would be a five per cent reimbursement on the interest actually charged by the identified financial institutions on the sanctioned projects. It was, therefore, resolved that a TUF scheme be made operational for the textile, jute, and cotton industries for five years with effect from 1 April 1999. The textile industry comprises cotton, wool, silk, synthetic fibre, and jute. Cotton textile manufacture, the predominant sub-sector in the textile industry, consists of both the organized and decentralized sectors, which use both powerlooms and handlooms.

The production of man-made fibre and yarn has increased significantly from 223 million kg in 1980/81 to 3046 million kg in 1999/2000. The production of fabrics registered an increase from 27 898 million square metres in 1993/94 to 37 436 million square metres in 1997/98. While the share of mill sector in fabric production declined from 7.8% in 1995/96 to 7.3% in 1999/2000, the share of powerlooms decreased from 76.2% to 72.4% during the same period (Table 2.33).

The number of cotton and man-made fibre textile mills (comprising cotton yarn, blended yarn, and other man-made fibre yarn manufacturing units and the composite units) rose from about 700 in the beginning of the 1980s to 1782 by the end of March 1998. During the same period, the spindleage capacity increased from 21 million spindles to about 34 million spindles. The growth process in the spinning sector has been marked by the installation of more rotors, which now number 313 000. The weaving capacity declined from 1980 to 1998 by about 85 000 looms. However, in 1990, this was compensated by the emergence of the decentralized powerloom sector in a big way. In recent years, a number of EOUs (export-oriented units), mainly for the production of cotton yarn, have come up. The number of EOUs has increased from 30 in 1994 to 82 in 1998. Textile exports have grown from 6600 million dollars in 1992/93 to 11 389 million dollars in 1996/97.

About 81% of the textile mills still remain in the private sector, while 8.5% of the units are in the cooperative sector, and 10.5% in the public sector (central and state). The private sector mills account for about 69% of the spindle capacity and 56% of the loom capacity, while the remaining 27% of the spindle capacity and 45% of the loom capacity are shared by both the public sector and cooperative sector units.

The textile industry accounts for nine per cent of the total commercial energy-use in India (TERI 1996). Coal and furnace oil are used for process heat requirements. All textile mills, except those around Mumbai, use coal in their boilers. An estimated 80%–90% of the electricity used is motive power for driving pumps, motors, drives, etc.

The energy consumption in the various sub-sectors of the textile industry may be noted in Table 2.34. Coal is the major fuel consumed in this sector, although its share, both in absolute and relative terms, as against oil and gas and electricity, has declined. The share of coal in the total energy consumed declined from nearly 50% in 1985 to 41% in 1994/95. During this period, the share of oil and gas increased by 10%, while the share of electricity remained more or less constant at 30% (TERI 1998).

Fuel and power account for 12%–15% of the total cost of production at present, registering an increase of 3%–4% of the total production cost in 1984/85 (TERI 1996). The overall energy-saving potential in this sector is estimated to be 23%. The major energy-saving opportunities are listed below.

- Installation of radio frequency drier
- Use of smaller wrap diameter spindle
- Use of single-stage bleaching process
- Use of resin finishing
- Use of low energy bleaching process
- Rapidogen development
- Use of low-temperature curing of pigment prints
- Use of foam technique for printing and finishing.

In addition to these measures, there is the possibility of utilizing renewable sources of energy,

Table I Status of large and mini cement plants as on 31 December 2000

Size of cement plants	*Number of plants*	*Installed capacity* (MT)	*Cement production* (MT)
Large	116	116.3	95.94
Mini	300	9.0	6.24

Source CMA (2001)

specifically solar thermal applications for generating low-grade heat. Surveys show that 25%–30% of the mills have not adopted any energy conservation measures. It is estimated that in the mills that use steam, about 10% of the electricity requirements can be met by installing cogeneration equipment.

Cement

India is the third largest cement producing country in the world. Despite the rapid growth in this industry, the per capita consumption of cement in India (99 kg) is still among the lowest in the world. A number of developing countries have a per capita consumption that far exceeds India's; for example, the average for Latin America is 218 kg. Thus, there is a huge growth potential for the cement industry in the country. As on 31 December 2000, there were 116 large cement plants and about 300 mini plants in the country. The installed capacity has increased from 3.25 million tonnes in 1950 to 125 million tonnes by the end of 1999 (Table I). The overall growth of the cement industry for 1990/2000 is given in Table 2.38.

The Indian cement industry comprises a total of 158 large rotary kilns. About 94% of the total installed capacity of large plants is based on the energy-efficient dry process technology.

The industry is quite energy intensive, and the main source of energy is coal. There appears to be no discernible shift in the fuel-use pattern. The contribution of other fuel types, namely oil, gas, or other alternative waste fuels is negligible. For dry process plants, the thermal energy consumption ranges between 720 and 1000 kcal/kg of clinker and the power consumption is 86–143 kcal/tonne of cement. The lower figures are for the newly set-up modern plants whereas the higher values are for older plants. Although the new generation plants set up in India in the recent past have energy consumption comparable with the best and most energy-efficient plants in the world, there exists scope for improving energy efficiency in the relatively older installations. At least 10% savings in both thermal and electrical energy consumption is possible by adopting various energy conservation measures in many of the older units.

Some of the energy-efficient technologies that can be adopted in different sections of the cement plants are outlined below.

- *Raw material preparation section* Use of gyratory crushers and mobile crushers; use of VRM (vertical roller mills) instead of ball mills; use of external recirculation systems in VRMs; adoption of roller press technology and high efficiency separators in the grinding circuits.
- *Cement grinding* Use of VRMs with high efficiency separators and high-pressure roller press in various modes of operation; use of static V separators along with dynamic separators.
- *Pyroprocessing section* Installation of precalcinators and 5/6 stage preheaters with low-pressure drop cyclones, use of short kilns having lower L/D (length/diameter) ratio; new generation coolers having better heat recovery potential.

In addition, certain other areas like waste heat recovery from preheater/cooler exit gases for power generation, use of secondary materials like slag and fly ash for manufacturing blended cement, and use of waste fuels as part replacement for coal offer enormous opportunities to reduce specific energy consumption in the cement sector.

Iron and steel

The iron and steel industry is the largest consumer of energy in the industrial sector. It consumes about 10% of the total energy in the country. Energy costs constitute 30%–35% of the total production costs of iron and steel. Two processes for production are common in India, namely integrated steel plants (technically defined as BF-OH [blast furnace-open hearth] and BOFs [basic oxygen furnaces]) and mini-steel plants (scrap or sponge iron-based EAFs [electric arc furnaces]). India has 269 EAFs, with a total steel-making capacity of 9.3 million tonnes a year. During 1999/2000, the actual production of finished steel was 25 million tonnes. Crude steel production in India and a few other major producing countries is given in Tables 2.42 to 2.44. The consumption of finished steel was 24 million tonnes in 1998/99 (a 3% increase from 1997/98).

The primary sources of energy utilized by integrated steel plants are coking coal, non-coking coal, liquid hydrocarbons, and electricity, of which coking coal accounts for 65%–80% (FRIC 1996). The process of making iron in blast furnaces accounts for nearly 70% of the total energy consumption at the plant.

Electricity is an important source of energy for making steel. Most of the integrated steel plants have their own captive power plant for electricity generation. The EAFs are too small for captive power plants to be economically viable. The small size of furnaces and erratic power supply have led to high electricity consumption in Indian EAFs ranging from 500 to 880 kWh/tonne of crude steel. Electricity consumption increased from 530 kWh/tonne to 604 kWh/tonne of production. Recently, the private sector has set up such plants with annual production capacities ranging from 25 000 to 30 000 tonnes up to 1 million tonne.

Although substantial energy conservation measures have been adopted in integrated steel plants in India, their performance is sub-standard compared with those in other countries. Efforts are on to reduce energy consumption further by importing good-quality coking coal, phasing out open hearth furnaces for steel-making, and the more rapid introduction of continuous casting. The Ninth Plan envisages to (1) produce 58 million tonnes of finished steel by 2002–07, (2) promote more private investment, and (3) achieve the export target of 6 million tonnes of finished steel by 2001/02. It also recommends that steel plants adopt the ISO 9000 series certification and TQM (total quality management).

Pulp and paper

The pulp and paper industry is the sixth largest energy consumer in the country. As of now, India has 515 pulp and paper mills with an installed capacity of 7.20 million tonnes a year. The Indian paper industries use a broad mix of raw materials like wood/bamboo (37%), agro-residues (31%), and waste paper (32%) (Rao, Bhattacharya, and Banerjee 1998). The product range of the industry can be broadly classified into the paper and paper board segment and the newsprint segment. The paper and paper board segment can be further classified into writing and printing paper, wrapping and packaging paper, paper board, and special paper.

There is low capacity utilization in the pulp and paper industry because of an acute shortage of raw materials, erratic power supply, shortage of fuel, market forces, etc. India's per capita paper consumption is 3.6 kg a year, while the world average is 45.6 kg a year. It is expected to rise to 5 kg a year by 2001 (Rao, Bhattacharya, and Banerjee 1998).

Energy accounts for 30% of the total manufacturing cost and is rising every year. In India, the average annual production capacity of a plant is 10 000 million tonnes, which is low compared to the Asia-Pacific region (85 000 million tonnes) and South-East Asia (50 000 million tonnes). This is because of the high cost of setting up a new plant. As compared to the larger mills, which are more efficient and have low costs of production, the smaller mills do not have chemical recovery systems and cogeneration, thus making them less efficient and increasing the production costs.

Chlor-alkali

The chlor-alkali industry comprises mainly caustic soda, soda ash, and chlorine manufacturing plants. Caustic soda and its co-product chlorine are used in large quantities in the production of organic chemicals and plastics, in the pulp and paper industry, aluminium industry, water and waste water treatment facilities, and in a number of other industries.

At present, there are 40 caustic soda and 7 soda ash plants operating in India. Out of 40 caustic soda plants, 17 plants have the membrane cell process, 9 plants have the mercury and membrane cell processes, 12 plants have only the mercury cell process, and 1 has the diaphragm process, which is being phased out. These units now have a surplus manufacturing capacity. The average caustic soda plant size in India is about 150 tpd (tonnes per day), which is very small compared to the average plant size of 500 tpd in developed countries.

Caustic soda is mainly produced by the electrolysis of sodium chloride (common salt). In the electrolysis process, three types of cells are used: diaphragm cell, mercury cell, and membrane cell. In India, the caustic soda industry began with the diaphragm electrolytic cells. Mercury cells are widely used as they consume less power and produce almost 50% concentrated caustic liquor, which is sold as it is or in the form of flakes. Heavy metal pollution due to the presence of mercury in effluents is a hazard. Removing mercury from the effluents has, however, effectively solved this problem. The share of membrane cell in the total production grew from 1.7% in 1987/88 to 68.5% in 1999/2000. This is attributed to the commissioning of new plants with membrane cell process in the recent years. The membrane cell process is more energy efficient and environment-friendly than other major processes of production. Considering the importance of energy efficiency and the non-polluting nature of the process for caustic soda production, the Central Pollution Control Board has recommended the membrane cell process for the new plants. The caustic soda industry is highly capital intensive.

The main steps in the manufacturing process of soda ash comprise pulverizing the salt, brine purification, absorption of ammonia in brine (ammoniated brine), and carbonation to form sodium bicarbonate and ammonium chloride. The sodium carbonate precipitate is filtered in rotary vacuum filters and calcined in rotary calciners to obtain soda ash. In India, the different processes adopted for soda ash manufacturing are (1) the Solvay process (2) the modified Solvay (dual) process, and (3) the Akzo dry lime process.

Some chlor-alkali units have installed turbogenerators to meet a large part of their power requirements. A substantial quantity of steam is required at low pressure for the processes.

The overall specific energy consumption of the Indian caustic soda industry has varied from 2.3 to 3.5 giga calories per tonne, which is substantially higher than the international norms. In the chlor-alkali industry, energy accounts for 50%–65% or more of the total cost of production. Therefore, energy conservation has become a matter of concern, forming an integral part of plant operations. The energy-saving potential in the chlor-alkali industry is estimated at 15% of the total energy use by the sector. The future of the caustic soda industry is not very bright as is evident from the above. However, by adopting more energy-efficient and environment-friendly membrane cell technology, better capacity utilization and cost-cutting measures, the Indian caustic soda industry should be able to save a large amount of energy and survive. In the soda ash sector, the major energy-saving measures are (1) the use of improved heat exchangers for the ammonia recovery system and (2) the use of dry lime in the ammonia still for heat recovery.

References

CMA. 2001
Basic Data
New Delhi: Cement Manufacturers' Association.

FRIC. 1996
Basic Survey on Energy-Intensive Industries in India
New Delhi: Fuji Research Institute Corporation.

Rao A R K, Bhattacharya J P, and Banerjee S. 1998
Current status of Indian paper industry and outlook for investment in near future
Journal of the Indian Pulp and Paper Technical Association **10**(4): 1–4

TERI. 1996
Energy efficiency support project: sector analysis
New Delhi: Tata Energy Research Institute.
[Report No. 95IE56]

TERI. 1998
Database development project for India
New Delhi: Tata Energy Research Institute.
[Report No. 97ED51]

Table 2.23 Energy consumption in industry: 1993/94 to 1998/99

Fuel consumption	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*
Electricity purchased from utilities (GWh)	31 908	32 061	33 941	32 412	32 588	–
Self-generated electricity (GWh)	26 862	29 709	32 438	35 088	37 442	–
Electricity (GWh)[a]	58 770	61 769	66 379	67 500	70 031	–
Fuel oil (thousand tonnes)	3 603	3 944	4 836	4 691	4 865	4649
Naphtha (thousand tonnes)	3 191	3 400	3 669	4 015	4 716	6237
High-speed diesel (thousand tonnes)[b]	1 512	1 783	2 386	2 816	2 921	2956
Light diesel oil (thousand tonnes)[b]	625	641	700	633	621	660
Liquefied petroleum gas (thousand tonnes)[c]	635	654	737	774	766	831
Coal (million tonnes)[d]	95	104	95	96	–	–

[a] having installed plant capacity of 1 MW and above

[b] excluding plantation and food

[c] including commercial sector

[d] consumption and supply of raw coal includes steel and washery, cement, cotton, jute, paper, brick, and other industries

Sources

1 CEA. ***Public Electricity Supply, All India Statistics, General Review*** (various issues). New Delhi: Central Electricity Authority.

2 MoC. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

3 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economic and Statistics Division, Ministry of Petroleum and Natural Gas.

4 FAI. 1998. ***Fertilizer Statistics. 1997/98***. p. II 65. New Delhi: Fertilizer Association of India.

Table 2.24 Installed capacity (**thousand tonnes**), production (**thousand tonnes**), and capacity utilization (%) in the fertilizer industry: 1994/95 to 1999/2000

Parameter	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Nitrogenous						
Installed capacity	8998.0	9134.2	9468.2	10 473.7	10 559.3	11 077.8
Production	7944.3	8768.8	8593.1	10 083.0	10 477.3	10 873.2
Capacity utilization	91.0	98.5	93.2	96.2	99.2	98.2
Phosphatic						
Installed capacity	2873.0	2982.0	3027.3	3 135.3	3 346.8	3 760.7
Production	2562.6	2593.5	2578.6	3 058.3	3 181.2	3 407.5
Capacity utilization	90.9	90.7	86.1	97.5	95.1	90.6

Source

FAI. ***Fertilizer Statistics*** (various issues). New Delhi: Fertilizer Association of India.

For more details, please see TEDDY ONLINE+ [Section: Industry (fertilizers)]

Table 2.25 Imports (**thousand tonnes**) of fertilizers: 1994/95 to 1999/2000

Type	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Nitrogenous	1473.2	2008.2	1156.4	1377.4	657.0	855.9
Phosphatic	376.1	686.3	218.5	715.9	984.8	1534.1
Potash	1281.7	1424.3	666.5	1437.3	1558.1	1773.9
All India	3131.0	4118.8	2041.4	3530.6	3199.9	4163.9

Source

FAI. 2000. ***Fertilizer Statistics 1999/2000.*** New Delhi: Fertilizer Association of India.

Table 2.26 Energy consumption in the fertilizer industry: 1993/94 to 1998/99

Energy form	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*
Naphtha (thousand tonnes)	2172	2495	2669	3019	3404	3881
Furnace oil (thousand tonnes)	1160	1507	1770	1374	1235	926
Low sulphur heavy stock/hot heavy stock (thousand tonnes)	1052	1001	1107	1354	1621	1910
High-speed diesel/light diesel oil (thousand tonnes)	12	21	29	26	30	35
Coal (million tonnes)	5.0	4.3	4.3	4.4	4.6	4.1
Electricity (GWh)[a]	5700	6203	5946	7213	6586.81	–

[a] includes energy used out of self-generation

Sources

1 CEA. ***Public Electricity Supply, All India Statistics, General Review*** (various issues). New Delhi: Central Electricity Authority.

2 MoC. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

3 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economic and Statistics Division, Ministry of Petroleum and Natural Gas.

4 MoC. 2001. ***Annual Report 2000/01.*** New Delhi: Ministry of Coal.

Table 2.27 Specific energy consumption (Gcal/tonne) of ammonia: 1988/89 to 1997/98

Feedstock	*1988/89*	*1989/90*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1997/98*
Gas	10.00	9.60	9.60	9.60	9.50	9.41	8.86
Naphtha	12.23	12.35	11.92	11.74	11.73	11.70	10.95
Fuel oil	14.32	14.36	15.08	13.53	13.90	–	13.31
Coal	33.84	38.85	39.13	39.65	42.69	–	48.13

Sources

1 TERI. 1995. ECOMILES (***Environmental considerations and options in managing India's long-term energy strategy***). p. 40. New Delhi: Tata Energy Research Institute. 241 pp.

2 TERI. 1998. **Energy-efficiency support project – Fertilizer sector report.** New Delhi: Tata Energy Research Institute.

For more details, please see TEDDY ONLINE+ [Section: Industry (fertilizers)]

Table 2.28 Specific energy consumption (**Gcal/tonne**) of phosphatic fertilizer plants: 1991/92 to 1993/94

Plant and products	*1991/92*	*1992/93*	*1993/94*
Gujarat State Fertilizer Corporation, Vadodara			
Sulphuric acid	−0.47	−0.46	−0.58
Phosphoric acid	1.72	1.58	1.64
Di-ammonium phosphate	0.22	0.20	0.13
Gujarat Narmada Fertilizer Corporation, Bharuch			
Nitrophosphate	1.42	1.41	1.23

Note
Negative value implies that the total energy input is less than the energy equivalent of the steam generated in waste-heat boilers.

Source
Compiled by TERI, New Delhi.

Table 2.29 Capacity (**thousand tonnes**), production (**thousand tonnes**), and capacity utilization (%) of aluminium companies: 1999/2000

Company	*Location*	*Capacity*	*Production*	*Capacity utilization*
Indian Aluminium Company Ltd	Belgaum (Karnataka), Alupuram (Tamil Nadu), Hirakud	117	43.5	37.18
Bharat Aluminium Company Ltd	Korba (Madhya Pradesh)	100	96.5	96.50
National Aluminium Company Ltd	Angul (Orissa)	218	212.7	97.56
Hindalco Industries Ltd	Renukoot (Uttar Pradesh)	242	248.9	102.86
Madras Aluminium Company Ltd[a]	Mettur (Tamil Nadu)	25	1.6	0.06
Total	–	702	603.2	85.92

[a] production restarted in late 1994/95

Source
Compiled by TERI, New Delhi

For more details, please see TEDDY ONLINE+ [Section: Industry (fertilizers)]

Table 2.30 Installed capacity (**thousand tonnes**), production (**thousand tonnes**) and capacity utilization (%) of the aluminium industry: 1993/94 to 1999/2000

Item	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Installed capacity	625.0	625.0	–	–	–	–	–
Production	460.7	467.2	527.0	509.6	550.0	536.8	497.9
Capacity utilization	74.4	76.5	–	–	–	–	–

Sources
1 Compiled by TERI, New Delhi.
2 MoF. 2001. ***Economic Survey 2000/01***. New Delhi: Ministry of Finance.

Table 2.31 Specific energy consumption per tonne of aluminium: 1992/93 to 1999/2000

	Specific energy consumption in smelting per tonne of aluminium			
	Electrical			
Plant and year	kWh	(GJ/tonne)	*Thermal* (GJ/tonne)	*Total* (GJ/tonne)
National Aluminium Company Ltd				
1996/97	16 198	58.310	3.600	61.910
1997/98	15 911	57.280	4.514	61.794
1998/99	17 725	63.810	5.593	69.403
1999/2000	15 549	55.980	4.665	60.645
Hindalco Industries Ltd				
1996/97	15 063	54.23	2.500	56.730
1997/98	15 359	55.29	2.679	57.969
1998/99	15 332	55.19	2 754	57.944
1999/2000	15 217	54.78	2.838	57.618
Bharat Aluminium Company Ltd				
1992/93	17 772	63.949	0.707	64.657
1993/94	18 173	65.392	0.845	66.238
1994/95	18 022	64.849	1.109	65.958
1996/97	18 083	65.090	0.900	65.990
Indian Aluminium Company Ltd				
1994/95 (Alupuram)	17 385	62.557	0.774	63.331
1994/95 (Hirakud)	16 625	59.822	0.636	60.458
1999/2000 (Hirakud)	15 483	55.74	–	–
1994/95 (Belgaum)	17 921	64.486	0.854	65.339
1996/97 (Avg. of 3)	17 067	61.440	2.200	63.640
Total for all units (1999/2000)	16 354	58.870	–	–
Madras Aluminium Company Ltd				
1996/97	16 754	60.310	2.200	62.510

Source
Compiled by TERI, New Delhi.

Table 2.32 Performance parameters (per tonne of calcined alumina) of Indian aluminium plants: 1994/95

				Indian Aluminium Company Ltd	
Parameter	*Hindalco Industries Ltd*	*Bharat Aluminium Company Ltd*	*National Aluminium Company Ltd*	*Belgaum*[a]	*Muri*
Bauxite (tonnes)	2 73	2.63	2.77	2.80	3.07
Caustic (kg)	100.00	80.00	60.00	110.00	140.00
Lime (kg)	148.00	229.10	57.30	–	–
Coal (tonnes)	0.95	0.59	0.70	–	1.35
Steam (tonnes)	4.10	3.34	–	–	–
Fuel oil (litres)	80.00	130.00[a]	90.00	231.00[b]	110.00
Power (kWh)	428.00	470.00	413.00	268.00	–
Total energy consumption (GJ)	16.36	16.51	13.21	–	–

[a] does not use coal for steam generation leading to very high consumption of fuel oil
[b] includes consumption for steam generation

Source
Compiled by TERI, New Delhi.

Table 2.33 Production by the textile industry: 1994/95 to 1999/2000

Products	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]
Jute textiles (thousand tonnes)	1374	1433	1401	1678	1587	1591
Cloth (million m²)						
Cotton cloth						
Mill sector	1262	1159	1222	1238	1111	1105
Decentralized sector	15751	17741	18619	18754	16837	17884
Sub-total	17013	18900	19841	19992	17948	18989
Mixed and blended cloth						
Mill sector	746	602	488	466	444	379
Decentralized sector	2915	3423	4400	5285	5256	5534
Sub-total	3661	4025	4888	5751	5700	5913
Man-made fibre fabrics						
Mill sector	263	258	247	244	230	230
Decentralized sector	7232	8277	9322	10909	11665	13495
Sub-total	7495	8535	9569	11153	11895	13725
Spun yarn (by cotton textile mills) (million kg)						
Cotton	1696	1894	2148	2213	2022	2204
Mixed and blended	346	395	484	583	595	621
100% non-cotton	158	196	162	177	191	221
Filament yarn (thousand tonnes)						
Cellulosic						
Viscose	59	61	57	57	61	49
Acetate	37	34	–	–	–	–
Sub-total	96	95	57	57	61	61
Synthetic						
Nylon	39	42	38	30	29	26
Polyester	298	376	493	669	745	801
Sub-total	337	418	531	699	774	827
Staple fibre (thousand tonnes)						
Cellulosic						
Viscose	173	194	179	188	178	202
Acetate	–	–	–	–	–	–
Sub-total	173	194	179	188	178	202
Synthetic						
Polyester	221	228	325	437	523	551
Acrylic	83	74	83	79	79	79
Sub-total	304	302	408	518	602	630

[a] provisional

Source
MoF. 2001. ***Economic Survey 2000/01***. New Delhi: Ministry of Finance.

Table 2.34 Energy consumption in the textile industry: 1993/94 to 1997/98

Fuel	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*
Electricity (GWh)					
Textile	8004.70	8199.10	9378.67	9004.40	8784.83
Jute	741.80	787.00	855.44	772.80	909.83
Sub-total	8746.50	8986.10	10 234.11	9777.20	9694.66
Coal (million tonnes)					
Jute	–	0.10	0.10	0.10	–
Cotton	1.80	1.80	1.20	1.30	–
Sub-total	–	1.90	1.30	1.40	–
Fuel oil (thousand tonnes)[a]	714	651	673	695	–

[a] includes furnace oil, low sulphur heavy stock and hot heavy stock.

Sources

1 CEA. ***Public Electricity Supply, All India Statistics, General Review*** (various issues). New Delhi: Central Electricity Authority.
2 MoC. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.
3 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Industry (textiles)]

Table 2.35 Energy intensity of the textile industry

Product (per metre)	*Electricity* (kWh)	*Coal* (kg)
Cotton	0.9	0.8
Polyester	–	1.3
Jute	545.0	23.2

Source

Inter-Ministerial Working Group. Utilization and conservation of energy sectoral reports (various issues). New Delhi: Government of India.

Table 2.36 Power consumption (% of total) in different types of mills by section

Mill type	*Spinning preparatory*	*Ring frame*	*Weaving preparatory*	*Weaving*	*Humidification*	*Wet processing*	*Lighting*	*Others*
Spinning mills	21.0	55.0	4.5	–	14.0	–	3.5	2.0
Composite mills	12.5	29.3	5.0	12.8	18.5	10.0	4.0	7.9

Source

TERI. 1995. **Sector study report on energy efficiency in the Indian textile industry.** Submitted to the Industrial Credit and Investment Corporation of India, Mumbai. p.25. New Delhi: Tata Energy Research Institute. 58 pp.

Table 2.37 Specific electricity consumption in textile mills

Mill type and range	*kWh/kg*	*kWh per spindle shift*	*kWh per loom shift*
Spinning mills			
Maximum	6.60	0.420	–
Minimum	2.58	0.291	–
Average	4.63	0.350	–
Composite mills			
Maximum	19.51	1.120	103.00
Minimum	6.70	0.359	19.81
Average	13.10	0.800	35.29

Source
TERI. 1996. **Sector analysis: textile industry.** Prepared for the Asian Development Bank Energy Efficiency Support Project. p.19. New Delhi: Tata Energy Research Institute. 34 pp.

Table 2.38 Growth of cement industry (**million tonnes**): 1990 to 2000

Year	*Capacity*	*Cement production*	*Growth* (%)
1990	58.12	44.87	6.7
1991	60.61	49.47	10.3
1992	62.46	50 87	2.8
1993	66.90	52.78	3.8
1994	73.19	57.57	9.1
1995	82.06	62.08	7.8
1996	90.17	68.86	10.9
1997	99.92	74.75	8.6
1998	108.41	79.42	6.2
1999	109.44	91.72	15.5
2000	116.30	95.94	4.6

Source
CMA. 2001. ***Basic Data of Indian Cement Industry 2001.***
New Delhi: Cement Manufacturers' Association.

Table 2.39 Fuel consumption in the cement industry: 1993/94 to 1998/99

Fuel	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*
Electricity (GWh)	5569.9	5734.1	6916.3	7087.0	7519.5	–
Coal (million tonnes)	10.36	11.22	11.00	11.25	18.20	–
Petroleum products (thousand tonnes)[a]	291	346	514	549	625	655

[a] includes high-speed diesel, light diesel oil, furnace oil, low sulphur heavy stock, and hot heavy stock.

Sources

1 CEA. ***Public Electricity Supply, All India Statistics, General Review*** (various issues). New Delhi: Central Electricity Authority.

2 MoC. ***Coal Directory of India*** (various issues). Kolkata: Coal Controller's Organization, Ministry of Coal.

3 MoPNG. ***Indian Petroleum and Natural Gas Statistics*** (various issues). New Delhi: Economic and Statistics Division, Ministry of Petroleum and Natural Gas.

For more details, please see TEDDY ONLINE+ [Section: Industry (cement)]

Table 2.40 Trends in variety of cement production (**million tonnes**): 1995 to 2000

Year	*Ordinary Portland cement*	%	*Portland Pozzolana cement*	%	*Portland blast furnace slag cement*	%	*Others*	%	*Total*
1995	41.17	70.01	10.69	17.99	5.83	11.00	0.66	1.00	58.35
1996	47.57	69.08	13.39	19.45	7.26	10.54	0.64	0.93	68.86
1997	52.59	70.35	14.13	18.90	7.52	10.06	0.51	0.68	74.75
1998	56.52	71.17	14.83	18.67	7.58	9.54	0.49	0.62	79.42
1999	61.57	67.13	20.15	21.97	9.34	10.18	0.66	0.72	91.72
2000	60.56	63.13	24.44	25.47	10.14	10.57	0.80	0.83	95.94

Source

CMA. 2001. ***Basic Data of Indian Cement Industry 2001***. New Delhi: Cement Manufacturers' Association.

Table 2.41 Specific energy consumption in the cement industry

Country and process	*Thermal* (Gcal/tonne of clinker)	*Electrical* (kWh/tonne of cement)
India		
Dry with precalcinator[a]	0.81	110
Dry with suspension preheater[b]	0.88	118
Wet process[c]	1.48	122
Japan (1990)		
Dry	0.72	100
Germany (1990)		
Dry	0.80	108
Italy (1990)		
Dry	0.80	118
Wet	1.50	109
United Kingdom (1990)		
Dry	0.90	131
Wet	1.60	105
USA (1994)		
Dry	0.96	145
Wet	1.30	133
China (1990)[d]		
Average for all plants	1.30	106

[a] weighted average of 34 units
[b] weighted average of 11 units
[c] weighted average of 10 units
[d] China had nearly 61% wet process production in 1990

Sources

1 CII.1995 ***Specific Energy Consumption Norms in India: cement industry.*** Chennai: Confederation of Indian Industry.
2 CEC. 1993. **Energy technology in the cement industrial sector.** Directorate General (DGE), XVII. Brussels: Commission of European Communities. 208 pp.
3 ECN. 1994. ***Cement in Development· energy and environment.*** The Netherlands: The Netherlands Energy Research Foundation. 126 pp.
4 Uschikawa H. 1996. ***Present Problems in Cement Manufacturing Industry and Environmental Control in Cement Industry.*** Vol.2, Part II, pp 533-578, edited by S N Ghosh and S N Yadav. New Delhi: Akademia Books International.
5 Martin N, Worrell E, and Price L. 1999. **Energy efficiency and carbon dioxide emissions reduction opportunities in the US cement industry.** Ernest Orlando Lawrence Berkeley National Laboratory.

For more details, please see TEDDY ONLINE+ [Section: Industry (cement)]

Table 2.42 Finished steel production by producer (**million tonnes**): 1994/95 to 1999/2000

Producers	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Main producers						
Steel Authority of India Ltd	7.23	7.40	7.07	6.94	6.04	6.56
Bhilai Steel Plant	2.20	2.34	2.38	2.30	2.13	2.09
Bokaro Steel Plant	3.00	3.12	2.70	2.64	2.28	2.8
Durgapur Steel Plant	0.59	0.57	0.60	0.60	0.54	0.59
Rourkela Steel Plant	1.16	1.10	1.11	1.15	1.09	1.08
Indian Iron and Steel Company Ltd	0.28	0.27	0.28	0.25	0.26	0.24
Visakhapatnam Steel Plant	0.97	1.34	1.45	1.61	1.34	1.73
Tata Iron and Steel Company Ltd	1.37	1.79	1.98	1.90	2.27	2.67
Total (main producers)	9.57	10.53	10.50	10.45	9.65	10.96
Secondary producers	8.25	6.72	7.32	8.14	7.52	9.37
Total (finished steel)	17.82	17.25	17.82	18.59	17.17	20.33

Source

SAIL. 2000. ***Statistics for Iron and Steel Industry in India, 2000***. New Delhi: Steel Authority of India Ltd.

Table 2.43 Production (**million tonnes**) of ingot steel: 1994/95 to 1999/2000

Plant	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Bhilai Steel Plant	4.1	4.1	4.2	4.2	4.2	3.7
Bokaro Steel Plant	3.7	3.7	3.6	3.5	3.1	3.4
Durgapur Steel Plant	0.9	1.2	1.5	1.4	1.4	1.5
Rourkela Steel Plant	1.2	1.3	1.4	1.2	1.2	1.2
Indian Iron and Steel Company Ltd	0.3	0.3	0.4	0.3	0.3	0.3
Tata Iron and Steel Company Ltd	2.8	3.0	3.1	2.5	2.2	2.5
Visakhapatnam Steel Plant	1.7	2.1	3.2	2.8	2.9	3.4

Source

SAIL. 2000. ***Statistics for Iron and Steel Industry in India, 2000***. New Delhi: Steel Authority of India Ltd

Table 2.44 Crude steel production (**million tonnes**) by process: 1999

		Percentage of total			
Region/Country	*Production*	*Basic oxygen furnaces*	*Electric arc furnaces*	*Open hearth furnaces*	*Others*
European Union	155.2	61.9	38.1	–	–
North America	128 8	52.2	47.8	–	–
Asia	307.5	63.0	28.7	1.8	6.5
Former USSR	86.1	56.6	11.9	31.5	–

Source

IISI. 2000. **Statistics on energy in the steel industry.** www.worldsteel.org/trends_indicators/figures_6.html (Accessed on 23 May 2001). Brussels: International Iron and Steel Institute.

Table 2.45 Sponge iron production (**thousand tonnes**) by producer: 1990/91 to 1996/97

Name of the unit	*Location*	*Production*						
		1990/91	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*
Coal-based								
Sponge Iron India Ltd	Kothagudem, Andhra Pradesh	47	48	49	45	50	56	53
Orissa Sponge Iron Ltd	Palaspanga, Orissa	80	100	94	105	94	99	92
IPITATA Sponge Iron Ltd	Joda, Orissa	62	90	99	110	107	107	116
Bihar Sponge Iron Ltd	Chandil, Bihar	112	123	118	125	143	131	147
Sunflag Iron and Steel Company Ltd	Bhandara, Maharashtra	79	92	121	113	117	101	128
Jindal Strips	Raigarh, Madhya Pradesh	–	–	53	99	203	300	362
HEG Ltd	Durg, Madhya Pradesh	–	–	–	60	59	61	61
Kumar's Metallurgical Corporation Ltd	Nalgonda, Andhra Pradesh	–	–	–	25	46	7	14
Bellary Steel and Alloys Ltd	Bellary, Karnataka	–	–	10	30	45	53	53
Goldstar Steel and Alloys Ltd	Vizianagaram, Andhra Pradesh	–	–	45	80	76	41	20
Prakash Industries Ltd (commissioned in November 1993)	Champa, Bilaspur, Madhya Pradesh	–	–	–	65	148	147	190
Nova Iron and Steel Ltd	Bilaspur, Madhya Pradesh	–	–	–	–	40	135	138
Raipur Steels and Alloys Ltd	Raipur, Madhya Pradesh	–	–	–	25	27	48	69
Monnet Ispat Ltd	Raipur, Madhya Pradesh	–	–	–	9	53	89	78
Tamil Nadu Sponge Ltd	Salem, Tamil Nadu	–	–	–	5	7	7	8
Raigarh Electrodes Ltd	Madhya Pradesh	–	–	–	–	–	–	5
LLOYDS Metal & Engineers	Maharashtra	–	–	–	–	–	–	122
Rexon Strips Ltd	Orissa	–	–	–	–	–	–	12
Total		380	453	589	896	1215	1385	1668
Gas-based								
Essar Gujarat Ltd	Hazira, Gujarat	450	828	915	1438	1326	1500	1547
Vikram Ispat Ltd	Raigarh, Maharashtra	–	–	–	85	405	417	706
Nippon Denro Ispat Ltd	Raigarh, Maharashtra	–	–	–	–	446	1105	1126
Total		450	823	915	1523	2177	3022	3379
Grand total		830	1281	1504	2419	3392	4407	5047

Note

The installed capacity during 1992/93 was 98 000 tonnes for coal-based plants and 800 000 tonnes for gas-based plants.

Source

SAIL. 1998. ***Statistics for Iron and Steel Industry in India, 1998.*** p. 24. New Delhi: Steel Authority of India Ltd.

Table 2.46 Electricity generated, purchased, and consumed (GWh) in main steel plants: 1994/95 to 1999/2000

Plants	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Generated						
Bhilai Steel Plant	759.6	800.2	814.9	823.0	841	893
Bokaro Steel Plant	1243.4	1076.4	1092.0	1206.0	1277	1126
Durgapur Steel Plant	573.9	574.3	670.4	699.0	716	356
Rourkela Steel Plant	987.5	1011.7	1137.2	1180.9	1247	1265
Indian Iron and Steel Company Ltd	119.1	104.4	115.1	104.0	114	111
Tata Iron and Steel Company Ltd	1104.2	1115.1	1103.7	1118.9	1162	1137
Purchased						
Bhilai Steel Plant	1173.1	1137.2	1131.0	1135.0	1098	984
Bokaro Steel Plant	994.0	1160.7	1093.0	1014.0	910	1067
Durgapur Steel Plant	195.7	277.4	250.4	349.0	332	233
Rourkela Steel Plant	291.2	321.4	299.1	360.2	299	153
Indian Iron and Steel Company Ltd	122.2	133.8	132.1	129.0	108	102
Tata Iron and Steel Company Ltd	865.7	1095.7	1210.0	1198.0	1265	1350
Consumed						
Bhilai Steel Plant	1922.3	1926.9	1935.5	–	–	–
Bokaro Steel Plant	1848.3	1868.3	3011.0	3004.0	2996	–
Durgapur Steel Plant	564.7	624.5	689.9	–	–	–
Rourkela Steel Plant	1278.7	1333.1	1436.3	–	–	–
Indian Iron and Steel Company Ltd	–	–	–	–	–	–
Tata Iron and Steel Company Ltd	1969.9	2210.8	2313.6	–	–	–

Source

SAIL 2000. ***Statistics for Iron and Steel Industry in India, 2000.*** New Delhi: Steel Authority of India Ltd.

For more details, please see TEDDY ONLINE+ [Section: Industry (iron and steel)]

Table 2.47 Energy consumption per tonne in sponge iron plants

Fuel	*Coal-based*	*Gas-based*
Coal (tonnes)	1.2	–
Natural gas (m^3)	–	290
Electricity (kWh)	110	150
Light diesel oil (litres)	9	–
High speed diesel (litres)	3.5	–

Source

Chatterjee A. 1988. **A realistic assessment of the possibilities of direct reduction in India.** *Proceedings of the International Conference on Alternative Routes to Iron and Steel Under Indian Conditions.* Organized by the Indian Institute of Metals and Tata Iron and Steel Company

Table 2.48 Specific energy consumption (**Gcal/tonne**) in crude steel production: 1994/95 to 1999/2000

	Thermal					
Producer	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*2000*[a]
Bhilai Steel Plant	8.9	8.9	7.49	7.33	7.17	7.26
Bokaro Steel Plant	9.6	9.7	–	8.85	8.50	8.11
Durgapur Steel Plant	14.6	11.8	–	8.35	7.87	7.46
Rourkela Steel Plant	14.9	14.5	–	–	10.62	10.14
Indian Iron and Steel Company Ltd	35.2	34.1	–	–	–	9.64
Visakhapatnam Steel Plant	–	–	–	–	–	7.42
Tata Iron and Steel Company Ltd	–	–	–	–	–	7.41

[a] April-December

Source

1 Compiled by TERI, New Delhi.

2 SAIL. 2000. **Statistics for Iron and Steel Industry in India, 2000.** New Delhi: Steel Authority of India Ltd. (Data for 1996/97 to 1998/99).

Table 2.49 Installed capacity (**million tonnes**), production (**million tonnes**), and capacity utilization (%) in the paper industry: 1990/91 to 1998/99

Year	*Number of units*	*Installed capacity*	*Production*	*Capacity utilization*
1990/91	325	3.304	2.060	62
1991/92	326	3.364	2.111	63
1992/93	340	3.551	2.128	60
1993/94	380	3.790	2.329	61
1994/95	380	3.954	2.510	64
1995/96	395	4.200	–	–
1996/97	398	4.300	–	–
1997/98	406	6.120	4.150	68
1998/99	515	7.200	4.280	59

Source

IAPMA 1999. ***Status of Paper Industry***. New Delhi: Indian Agro Paper Mills Association.

Table 2.50 Specific energy consumption in different process centres (mills) in the paper industry

	Thermal (tonnes of steam per tonne of product)		*Electrical* (kWh/tonne of product)	
Process	*Indian*	*International*	*Indian*	*International*
Digester	2.70-3.90	1.90-2.30	58-62	43-46
Evaporator	2.50-4.00	1.80-2.20	–	–
Paper machine	3.00-4.00	1.80-2.00	465-475	410-415
Soda recovery plant	0.50-1.10	0.30-0.50	170-190	127-135
Bleach plant	0.35-0.40	0.20-0.25	88-92	66-69
Deaerator	0.80-1.20	0.45-0.70	–	–
Stock preparation	–	–	275-286	164-172
Chippers	–	–	112-128	92-98
Washing and screening system	–	–	145-155	116-122
Utilities and others	–	–	248-252	160-165
Total (rounded figures)	11.00-14.00	6.50-8.50	1500-1700	1150-1250

Source

DSIR. 1990. ***Technology Evaluation in Pulp and Paper Machinery Industry***. New Delhi: Department of Scientific and Industrial Research

Table 2.51 Specific energy consumption norms for the pulp and paper industry

Type	*Purchased energy* (million kcal/tonne)	*Steam* (tonnes/ tonne of product)	*Electrical* (kWh/tonne)
Writing and printing			
Integrated (wood pulp-based)	9.00	9.00	1400
Small and medium (agro-based)	8.70	5.80	1200
Small and medium (waste paper-based)	4.70	2.80	700
Kraft			
Integrated (wood pulp-based)	8.30	8.60	1280
Small and medium (agro-based)	5.50	4.10	650
Small and medium (waste paper-based)	3.70	2.30	550
Board			
Integrated (60% waste paper and 40% wood pulp)	7.50	7 00	1175
Medium (waste paper-based)	3.90	2.20	615
Small (waste paper-based)	4.28	2.40	685
Newsprint			
Large integrated	9.50[a]	4.72	2230
Large integrated	7.50[b]	–	–

[a] based on 100% wood pulp

[b] based on 100% bagasse

Source

Raghupathy S. 1994. **Specific energy consumption norms in Indian pulp and paper industry.** Paper presented at the *Confederation of Indian Industry Energy Summit 94*. Organized by the Confederation of Indian Industry (Southern Region), 25-27 August 1994, Chennai.

Table 2.52 Installed capacity, production, and capacity utilization in chlor-alkali industry: 1995/96 to 1999/2000

Parameter	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Installed capacity (thousand tonnes a year)					
Caustic soda	1673	1914	2029	2272	2251.1
Soda ash	1690	1840	1895	1895	1987.0
Production (thousand tonnes a year)					
Caustic soda	1308.7	1320.7	1419.5	1494.7	1511.0
Soda ash	1603.0	1615.7	1626.8	1478.1	1685.0
Capacity utilization (%)					
Caustic soda	78.2	69.0	70.0	66.0	67.1
Soda ash	94.9	87.8	85.8	78.0	84.8

Source
AMAI. ***Annual Report.*** (various issues). New Delhi: Alkali Manufacturers Association of India.

Table 2.53 Processwise production (**thousand tonnes**) of caustic soda: 1998/99 to 1999/2000

Process	*1998/99*	*1999/2000*
Mercury	514.8	475.6
Membrane	975.4	1035.5
Diaphragm	4.5	–
Total	1494.7	1511.1

Source
AMAI. 2000. ***Annual Report.*** New Delhi: Alkali Manufacturers Association of India.

Table 2.54 Specific energy consumption in different manufacturing sections in soda ash industry

Section	*Solvay process*		*Dual process*	
	Thermal (Gcal/tonne)	*Electrical* (kWh/tonne)	*Thermal* (Gcal/tonne)	*Electrical* (kWh/tonne)
Limestone calcination	1.0	35	–	–
Salt purification	0.1	10	0.1	10
Calcination of sodium bicarbonate	1.0	35	1.0	35
Crystallization, drying, and purification	1.0	25	1.0	25
Ammonia recovery	0.6	10	–	–
Manufacture of ammonium chloride	–	–	–	200
Utilities and general requirements	0.1	185	0.1	330
Total	3.8	300	2.2	600

Source

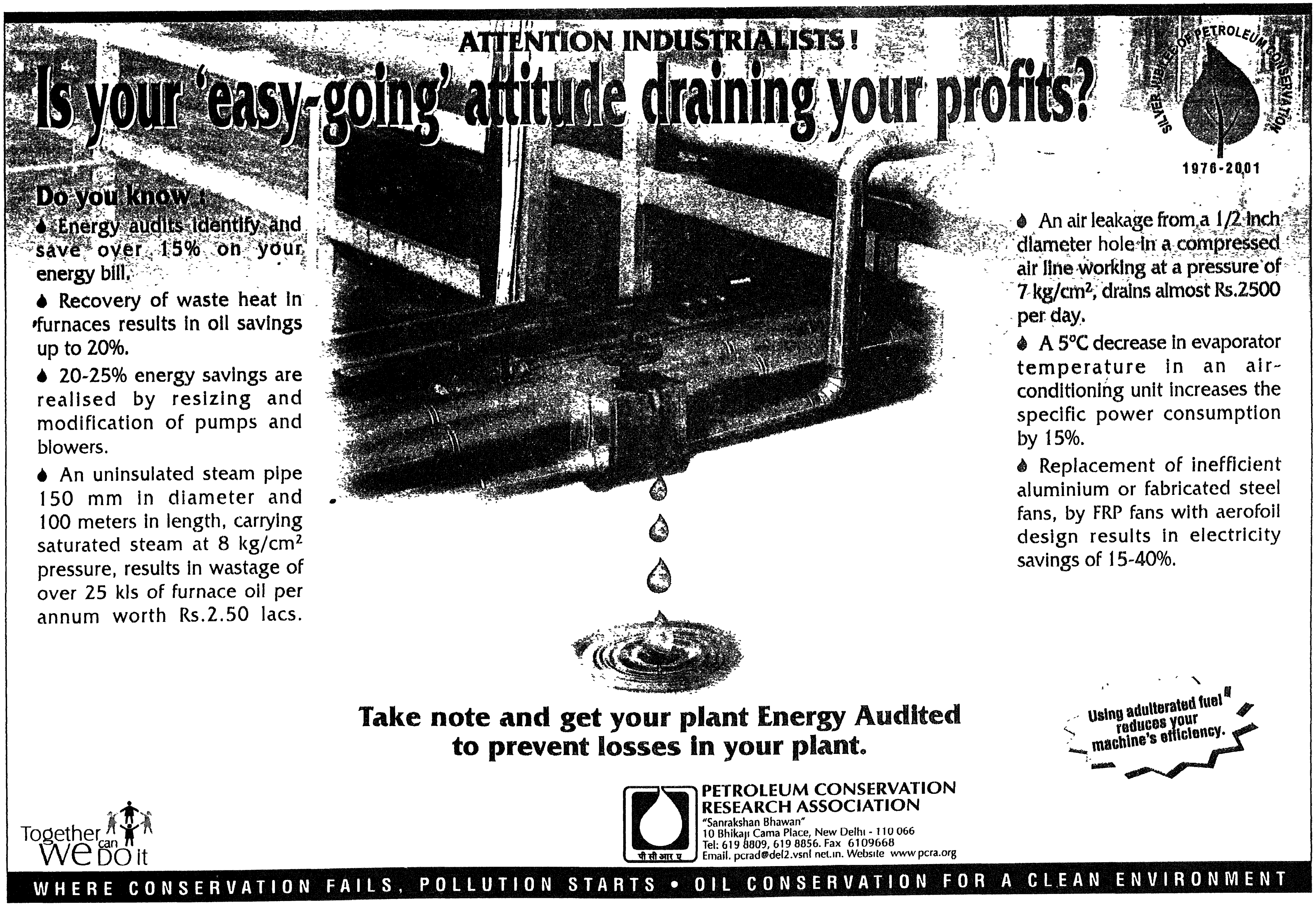
DSIR. 1994. **Report on the Technology Evaluation in Caustic Soda and Soda Ash Industry.**
New Delhi: Department of Scientific and Industrial Research.

Table 2.55 Total energy consumption (**kWh/tonne**) for manufacturing caustic soda lye (48.5%)

Power consumption (per tonne of caustic soda lye)	*Mercury process*	*Membrane process*
DC power	2833	2342
AC/DC losses	160	104
Auxiliary	307	254
Thermal energy for evaporation (equivalent electrical energy)	–	148
Total	3300	2848

Source

Reported by Alkali Manufacturers Association of India in 1999.



SILVER JUBILEE OF PETROLEUM CONSERVATION

1976-2001

ATTENTION INDUSTRIALISTS !

Is your 'easy-going' attitude draining your profits?

Do you know :

- Energy audits identify and save over 15% on your energy bill.
- Recovery of waste heat in furnaces results in oil savings up to 20%.
- 20-25% energy savings are realised by resizing and modification of pumps and blowers.
- An uninsulated steam pipe 150 mm in diameter and 100 meters in length, carrying saturated steam at 8 kg/cm^2 pressure, results in wastage of over 25 kls of furnace oil per annum worth Rs.2.50 lacs.
- An air leakage from a 1/2 inch diameter hole in a compressed air line working at a pressure of 7 kg/cm^2, drains almost Rs.2500 per day.
- A 5°C decrease in evaporator temperature in an air-conditioning unit increases the specific power consumption by 15%.
- Replacement of inefficient aluminium or fabricated steel fans, by FRP fans with aerofoil design results in electricity savings of 15-40%.

Using adulterated fuel reduces your machine's efficiency.

Take note and get your plant Energy Audited to prevent losses in your plant.

Together we can Do it

पी सी आर ए

PETROLEUM CONSERVATION
RESEARCH ASSOCIATION
"Sanrakshan Bhawan"
10 Bhikaji Cama Place, New Delhi - 110 066
Tel: 619 8809, 619 8856. Fax 6109668
Email. pcrad@del2.vsnl net.in. Website www pcra.org

WHERE CONSERVATION FAILS, POLLUTION STARTS • OIL CONSERVATION FOR A CLEAN ENVIRONMENT

TATA

"TATA Engineering is deeply conscious of its responsibility to protect the environment ... it has made investments to introduce environment friendly new processes in the plants and for use in vehicles"

-- *Ratan Tata, Chairman, TATA Engineering*

Recognising the importance of air pollution in Indian cities, TATA Engineering is playing a major role in reducing emission levels. It has made significant investments in R&D and in joint ventures with global leaders to introduce state-of-the-art technologies in India. In the automobile sector, it was the first to introduce stringent Euro I norms. This was followed by Euro II norms, reducing vehicular emissions by as much as 75 to 90%. All these were achieved well before these norms were mandated by law. Efforts are on to reach the future Euro IV emission standards at the same time as they are introduced in Europe. Now TATA Engineering is also developing alternate-fuel engines. TATA Engineering has always worked towards improving the environment, planting millions of trees and pioneering the introduction of cleaner and greener engines because of its concern for human health and life .

TATA Engineering believes that a clean environment is the concern of society, and a holistic approach is required to ensure it Advanced engine technology must be matched by better fuel quality, road network & infrastructure, traffic management, and improved vehicle maintenance

TATA ENGINEERING

Committed To Cleaner Environment Through A Holistic Approach

Transport

At a glance

- The contribution of the transport sector to the gross domestic product has grown annually by 7.12% between 1993/94 and 1997/98.
- *The transport sector is the second largest consumer of commercial energy, next to industry.*
- High-speed diesel and petrol contribute to 98% of energy consumed in the transport sector.
- Road transport is the most dominant mode of transport. Over 80% of passengers and 60% of freight are moved by road.
- Strategies towards improving energy efficiency and mitigating the environmental impacts of road transport include more stringent emission norms, improved vehicular technology, and cleaner fuel.
- One of the objectives of the Tenth Plan is to increase the scope of private participation in the transport sector.

Introduction

Transport plays a significant role in the overall development of the national economy. In 1997/98, the share of the transport sector in the GDP (gross domestic product) was 7.3% (520.02 billion rupees at 1993/94 prices). The contribution of the transport sector to real GDP has grown annually by 7.12% between 1993/94 and 1997/98. Of the total transport GDP during 1997/98, road transport contributed 60%, railways 22%, water transport 13%, and air transport 5% (Figure 1).

The GDP in the transport sector at current and constant prices is given in Table 2.56.

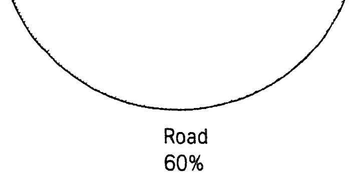


Figure 1 Contribution of various modes of transport to transport gross domestic product in 1997/98
Source CSO (2000)

Energy intensity of various modes of transport

The transport sector is the second largest consumer of energy, next only to the industry sector. Commercial energy consumption in the transport sector, about 98% of which is in the form of HSD (high-speed diesel) and petrol, grew at the rate of 3.1% a year between 1970/71 and 1980/81. It grew at a much faster rate of 4.9% a year between 1980/81 and 1990/91 and at 5.6% a year between 1990/91 and 1997/98.

Among the various modes of transport, road transport is the most dominant in terms of its contribution to the GDP and energy consumption in the transport sector. Railway is the other energy-intensive sector with high contribution to the GDP. The energy consumption by various modes of transport is given in Table I.

The HSD consumption by various transport sectors is given in Table II.

Road transport

Road transport is the most dominant form of transport for people and goods in India. There has been a tremendous increase in not only the number of motor vehicles registered but also the road network. The latter has risen from 0.9 million km in 1971 to 2.47 million km (excluding Jawahar Rozgar Yojna roads) in 1997 (Table 2.62). Over 80% of passengers and 60% of freight are moved by roads (MoF 2001). Roads cater to all types of traffic. Long distance traffic is served by national highways and state highways, inter- and intra-district traffic by major district roads, feeder traffic connecting rural centres of production to market outlets by other district roads, and local traffic by village roads and urban roads. Augmentation and upgradation of road networks with private sector involvement has been one of the priority areas for the road transport sector as also envisaged in the Ninth Five-year Plan.

Table I Energy consumption by mode of transport

Mode of transport	*Operating energy intensity* (BTU per passenger-km)
Scooters	625
Urban bus (Diesel)	184
Suburban rail (Electric)	27
Freight (BTU/Tonne-km)	
Diesel truck	1587.30
Train (Electric)	105.76

Source Planning Commission (1980)

Table II Consumption of HSD (high-speed diesel) by various transport sectors

Transport sector	*Percentage of total HSD consumption in 1999/2000*
Road transport	6.1
Aviation	0.1
Shipping	0.7
Railways	3.5
Other transport (including agriculture retail trade)	75.4

Source MoPNG (2001)

Road-based passenger transport has recorded high growth in recent years, especially since 1980/81. It is estimated that roads accounted for 44.8 billion passenger-km in 1951, which has since grown to 2515 billion passenger-km in 1996. Due to the increase in travel demand and the inefficient means of transportation, the consumption of fuel by the road transport sector has grown over the years. The consumption of HSD in the road transport sector has grown from 2.06 MT (million tonnes) in 1992/93 to 2.35 MT in 1998/99. Similarly, the petrol consumption in India has increased from 3.07 MT in 1990/91 to 5.57 MT in 1998/99. One of the major reasons for increased energy consumption in the road transport sector is that the travel demand in both passengers and freight traffic has increased rapidly (Figure 2). The share of roads in carrying passenger traffic in 1996/97 was about 80%. Also, the road infrastructure has not been able to cope with this upsurge in traffic volumes.

In freight traffic too, there has been a shift from rail to road (from 34.5% in 1970/71 to 60% in 1996/97). The freight traffic in 1996 was about

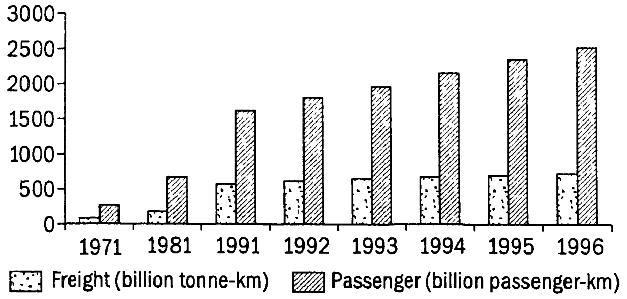


Figure 2 Increase in travel demand in passenger and freight traffic
Source MoST (1996)

720 billion tonne-km, which has increased from 12.1 billion tonne-km in 1951 (MoST 1996).

Energy-use planning is a critical aspect of the transport sector. Besides being major consumers of energy, different modes of transport use different forms of energy having varying degrees of efficiency and intensity. In India, at present, diesel is the only fuel available for commercial vehicles. Also, most goods vehicles in use are two-axle rigid trucks, which lack sophistication in technology and are not energy-efficient. The present modal split contributes to fuel inefficiency. Trucks are doing long hauls, which should normally be performed by the Railways.

Urban transport

The transport sector in urban areas has major problems due to rapid growth in the number of motor vehicles in the cities, far outpacing the growth in the urban population. The percentage of private vehicles (two-wheelers and cars) to the total number of registered vehicles in India has increased from 65% in 1971 to 82% in 1998. In the absence of any integrated urban transport policy, there has been a rapid growth in the share of personalized vehicles in the last two decades. The public transport system has not been able to keep pace with the growing demand in travel, resulting in the use of more personalized modes of transport in the urban areas, which leads to energy-inefficient means of travel. The per-seat-km energy consumed by a car is approximately five times higher than that of a bus. Poor road quality and poor maintenance of roads in urban areas have further obstructed the smooth movement of traffic, leading to congestion, which also increases the energy consumption in the transport sector. In the absence of adequate public transport and restraint and demand management measures, the occupancy rate of personalized vehicles in urban areas is very low, further increasing the energy intensity of passenger transport. Due to the increase in travel demand and inefficient means of travel, the fuel consumed by the road transport sector has also increased (Table 2.57).

Policy developments

With economic liberalization in the 1990s, new small-segment and fuel-efficient cars entered the Indian market, giving competition to cars running on the old, inefficient vehicular engine technology that was prevailing in India during that time.

The Eighth Five-year Plan suggested a three-pronged strategy for the conservation of energy in the transport sector.

- Give due weightage to energy consumption in the choice of mode of transport
- Promote energy-efficient modes by phasing out the old, obsolete units and inducting efficient state-of-the-art systems
- Improve the riding quality of vehicles
- Encourage multi-axle vehicles
- Discourage overloading of vehicles
- Reduce transport intensity.

The major policy developments in the road transport sector that help reduce the energy consumption aim at the following aspects.

- Improving vehicular technology and stringent emission norms
- Introducing cleaner fuel quality
- Promoting alternative fuels.

Improved vehicular technology and stringent emission norms

Vehicular emissions standards in India have been progressively tightened over the years, the details of which are provided in Table III. This has led the manufacturers to introduce more fuel-efficient engine designs, which would reduce the emission levels.

The use of catalytic convertors has been made mandatory since April 1995 in four metro cities and since 1 September 1998 in 45 cities. New passenger cars in Chennai, Delhi, Kolkata and Mumbai are allowed to register only if they are fitted with catalytic convertors. Emission norms for such vehicles had also been notified under Motor Vehicle Rules during January 1998. (CPCB 2000)

While there has been substantial progress in improving emission characteristics of vehicles in India, it is well recognized that current vehicle technologies in India are inferior compared to those in the developed world, especially for heavy-duty diesel vehicles. In India, diesel vehicles do not have particulate traps, which help to reduce the emissions of particulate matter. Buses are built on a truck chassis and designed for optimal speeds that are possible only on highways and not within the city. The largest segment of the vehicular fleet, namely two-wheelers, mostly uses the highly polluting two-stroke engine.

Table III Mass emission norms for Indian vehicles: notified till 2000 and auto industry plan beyond 2000

A. Petrol-driven four-wheeled passenger vehicles

		1 April 1996		*1 June 1999*	*1 April 2000*	*1 April 2004*[a]	*1 April 2007*[a]
Pollutant/fuel	*1 April 1991*	*Without catalytic converter*	*With catalytic converter*	*Euro 1*	*Euro 2*	*Euro 3*	*Euro 4*
CO (g/km)	14.3-27.1	8.68-12.40	4.34-6.20	2.72	2.2	2.3	1.0
HC (g/km)	2.0-2.9	–	–	–	–	0.2	0.1
HC + NO_x (g/km)	–	3.00-4.36	1.50-2.18	0.97	0.50	0.35	0.18
Maximum sulphur (PPM[b])	–	–	–	–	500	150	50

B. Petrol-driven two-wheelers

Pollutant/fuel	*1 April 1991*	*1 April 1996*	*1 April 2000 Bharat stage 1*	*1 April 2005*[a] *Bharat stage 2*	*1 April 2009*[a] *Bharat stage 3*
CO (g/km)	12-30	4.5	2.0	1.5	1.25
HC (g/km)	8-12	–	–	–	–
HC + NO_x (g/km)	–	3.6	2.0	1.5	1.25
Maximum sulphur (PPM)	–	–	–	150	50

C. Petrol-driven three-wheelers

Pollutant/fuel	*1 April 1991*	*1 April 1996*	*1 April 2000 Bharat stage 1*	*1 April 2005*[a] *Bharat stage 2*	*1 April 2009*[a] *Bharat stage 3*
CO (g/km)	12-30	6.75	4.0	2.25	1.88
HC (g/km)	8-12	–	–	–	–
HC + NO_x (g/km)	–	5.4	2.0	1.88	1.88
Maximum sulphur (PPM)	–	–	–	150	50

D. Diesel-driven vehicles with gross vehicle weight more than 3.5 tonnes

Pollutant/fuel	*1 April 1992*	*1 April 1996*	*1 April 2000 Euro 1*	*1 April 2003*[a] *Euro 2*	*Skip*[a] *Euro 3*	*1 April 2008*[a] *Euro 4*
CO (g/kWh)	14	11.2	4.5	4.0	2.1	1.50
HC (g/kWh)	3.5	2 4	1.1	1.10	0.66	0.46
NO_x (g/kWh)	18	14.4	8.0	7.00	5.0	3 5
PM[c] for >85 kW (g/kWh)	–	–	0.36	0.15	0.10	0 02
PM for <85 kW (g/kWh)	–	–	0.61	0.23	0.13	0.02
Maximum sulphur (PPM)	–	–	–	500	350	50

E. Diesel-driven vehicles with gross vehicle weight less than 3.5 tonnes

Pollutant/fuel	*1 April 1992*	*1 April 1996*	*1 June 1999 Euro 1*	*1 April 2000 Euro 2*	*1 April 2004*[a] *Euro 3*	*1 April 2007*[a] *Euro 4*
CO (g/km)	14.3-27.1	5.0-9.0	2.72	1.00	0.64	0.5
HC (g/km)	–	–	–	–	–	–
NO_x (g/km)	–	–	–	0.56	0.5	0.25
HC + NO_x (g/km)	2.7-6.9	2.0-4.0	0.97	0.7	0.56	0.30
PM (g/km)	–	–	0.14	0.08	0.05	0.025
Maximum sulphur	–	–	–	500	350	50

[a] proposed in the Indian auto industry road map to the government; [b] parts per million; [c] particulate matter

Sources IIP (1994); Bose (1998); Bose, Sundar, and Nesamani (2000); SIAM (2000); CONCAWE (1999); CPCB (1999)

Cleaner fuel quality

Unleaded petrol has been introduced in the country from 1 February 2000. The sulphur content in diesel was reduced from 1% to 0.5% in 1996 and was further reduced to 0.25% for metro cities and for the Taj Trapezium (the area around Taj Mahal) in 1997. In September 1999, the supply of diesel with sulphur content of 0.05% in Delhi for public transport and with sulphur content of 0.25% to other parts of the country was commenced in addition to the supply of ordinary diesel. As per the Supreme Court order, diesel with 0.05% sulphur has been supplied in National Capital Territory of Delhi and the National Capital Region since 30 June 2001. The developments in upgradation of fuel quality are given in the Table IV.

On 1 April 1999, the specifications for 2T oil became effective. To prevent the use of 2T oil in excess of the required quantity, premixed 2T oil dispensers have been installed in all petrol stations of Delhi. Sale of loose 2T oil has been banned since December 1998 (CPCB 1999). Further steps have been undertaken to check fuel adulteration by establishing independent autonomous testing centres/systems for fuel certification, including the monitoring of fuel quality at retail outlets.

The committee to formulate Auto-Oil Programme for the year 2005, constituted by the Ministry of Environment and Forests, has recommended future transport fuel quality in India (Table V).

Liquid fuels sold in India have less stringent specifications compared to those sold in other parts of the world. For example, the sulphur content in diesel sold in India is higher than that of diesel sold in the developed world. Recently, the government has tightened the fuel quality standards. However, the constraint is in terms of financial resources to build the required capability in the refineries.

Table IV Cleaner fuel quality in India

Stage	*Date*	*Specification*	*City/Region*
Petrol lead phase-out programme in India			
Phase-I	June 1994	Low-leaded (0.15 g/litre)	Cities of Delhi, Mumbai, Kolkata, and Chennai
Phase-II	1 April 1995	Unleaded (0.013 g/litre) (+low-leaded)	Cities of Delhi, Mumbai, Kolkata, and Chennai
Phase-III	1 January 1997	Low-leaded (0.15 g/litre)	Entire country
Phase-IV	1 September 1998 (Only unleaded fuel)	Ban on leaded fuel	NCT-Delhi (National Capital Territory of Delhi)
Phase-V	31 December 1998 (advanced to 1 September 1998)	Unleaded (0.013 g/litre) (+low-leaded)	All other capitals of states/Union territories and other major cities.
Phase-VI	1 January 1999	Unleaded only (0.013 g/litre)	NCR (National Capital Region)
Phase-VII	1 April 2000	Unleaded (0.013 g/litre) (+low-leaded)	Entire country
	June 2001	0.5% sulphur and 1% benzene	NCR
Diesel sulphur phase-out programme in India			
Phase-I	April 1996	Low sulphur* (0.5%)	Four metros and the Taj Trapezium
Phase-II	August 1997	Low sulphur (0.25%)	Delhi and the Taj Trapezium
Phase-III	April 1998	Low sulphur (0.25%)	Metro cities
Phase-IV	September 1999	Low sulphur (0.25%)	Entire country
Phase-V	April 2000	Low sulphur (0.05%)	NCR-Delhi for private vehicles
	October 2000	Low sulphur (0.05%)	For all vehicles in Mumbai
	June 2001	Low sulphur (0.05%)	Vehicles in all categories in NCT-Delhi and NCR
	October 2002	Low sulphur (0.05%)	Vehicles in all categories in NCR, Chennai, and Kolkata

* Before April 1996, the sulphur content in diesel was 1%.

Source CPCB (1999, 2000)

Table V Petrol and diesel specifications for 2005

Parameters	*Specifications*
Petrol	
Lead (g/litres) (max)	0.005
Olefins (vol%) (max)	18.0
Aromatics (vol%) (max)	45.0
Benzene (vol%) (max)	1.0
Oxygen (wt%) (max)	2.0
Sulphur (PPM) (max)	300
Diesel	
Cetane number (max)	50
Density (kg/m^3)	820-855
95% point (°C) (max)	360
Polycyclic aromatics (wt%) (max)	10
Sulphur (PPM) (max)	500

PPM - parts per million
Source CPCB (2001)

Alternative fuels

A CNG (compressed natural gas) pilot programme was launched by GAIL (Gas Authority of India Ltd) in 1993 in Delhi, Mumbai, Surat, and Vadodara. The programme predominantly aimed to convert petrol-using vehicles into vehicles using CNG as a fuel. The programme has had limited acceptance among the consumers due to inadequate supply of CNG, high cost of the conversion kit, and limited access to distribution outlets. Since December 1996, it has been made mandatory for all government vehicles to fit the 'CNG kit' or catalytic convertors. Also, these were exempted from customs duty in order to promote these kits. LPG (liquefied petroleum gas) is now being permitted as a transport fuel in India through amendments in the Motor Vehicles Act. Propane is also being promoted as an automobile fuel. There are three propane filling stations in NCT-Delhi as of March 2000 (CPCB 2000). Efforts have now been made to use battery-operated vehicles/electric vehicles for intermediate public transport and buses on a trial basis.

The government has initiated pilot projects on ethanol-petrol in Maharashtra and Uttar Pradesh. Five-per cent ethanol has been blended with petrol and it has been introduced in 300 outlets. Other than the pilot projects, R&D studies are also undertaken to monitor the impacts of ethanol-petrol blend fuels on various vehicles.

Very recently, the government has taken decisions to blend 5% ethanol with petrol. This will be implemented in two phases. During the first phase, Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Tamil Nadu, and Uttar Pradesh would be covered and during the second phase, the rest of the country. The government has also sanctioned 40 million rupees for R&D related to blending of ethanol with diesel.

Phasing out grossly polluting vehicles

In Delhi, commercial vehicles that are more than 15 years old are not allowed to ply on roads. Registration of new auto-rickshaws with a front engine has been banned from May 1996 and the registration of old defence service and government auctioned vehicles has been banned from April 1998. Other measures envisaged include replacement of all pre-1990 autos and taxis with new vehicles that use clean fuels and not allow eight-year old buses to ply except on CNG or other clean fuels (CPCB 2000).

The turnover rate of personal vehicles in India is low and the progressively stricter mass emission norms for new vehicles will have only limited impact. It is, therefore, necessary that there should be policy initiatives with regard to the 'in-use' vehicles as well. So far, these initiatives have largely been directed at commercial vehicles by way of not allowing those of a certain vintage to operate on city roads or requiring them to be retrofitted to use cleaner alternative fuels. The strategies for making 'in-use' vehicles less polluting would revolve around mandating stricter emission standards coupled with a requirement for periodic certification.

Review of draft approach paper to the Tenth Five-year Plan

The approach paper to the Tenth Five-year Plan focuses on improving the national highway rather than extension of the network itself. Top priority is given to ongoing work like the Golden Quadrilateral and North–South corridors. Preliminary actions will be taken to construct expressways where they can be commercially justified.

The focus will be on improving the road transport operation by rationalizing the road transport taxation structure, restraining the overloading of trucks, control of encroachments and unplanned ribbon development, and promoting road safety. Emphasis will be placed on private sector participation in improving the road transport operation, particularly in rural areas, without compromising on road safety considerations. Linking up all villages with all-weather roads is also to be targeted in the Tenth Plan (Planning Commission 2001).

Railways

Railways have traditionally played a dominant role in the Indian transport sector. However, despite being more energy-efficient, their share in freight and passenger traffic has declined over the years as there has been a significant shift to road transport from the mid-1980s onwards. In 1970/71, 67% of the passenger traffic was carried by roads as compared to 80% in 1996/97. This shift has manifested itself in the increasing number of vehicles on road and a higher rate of utilization of these vehicles.

There has been a shift from rail to road in freight traffic too. The shift of freight movement from rail to road has taken place despite railways having the advantage of higher speeds, bulk freight movement, carrying potential, economical land-use, etc. The reasons for this shift are listed below.

- The road sector has seen rapid growth even with very little capital investment from the government. Also private sector investment is spread out over a large population. The Railways are facing a tough competition from the trucking industry, where now the private sector provides these services. The commercialization of the road sector has increased the efficiency, reliability, and safety of services provided by them.
- The budgetary support for the Railways has declined to 23% of that specified in the Railways Plan in 1997/98 from 75% in the Fifth Plan. Thus, the Railways have been made to rely on its own revenue earnings. The resultant market borrowing has put a constraint on the ability of the Railways to raise resources internally due to a rising interest burden, thus delaying development projects.

Table VI Energy consumed by diesel and electric traction

Mode	*Fuel consumed*	*Energy consumed* (kcal)
Passenger traffic per 1000 GT-km		
Diesel train (litre)	5.08	54 813.2
Electric traction (kWh)	20.60	17 716.0
Freight traffic per 1000 GT-km		
Diesel train (litre)	3.13	30 039.0
Electric traction (kWh)	8.92	7 654.0

GT-km - gross tonne-kilometres
1 kg of high speed diesel used in diesel traction = 10 790 kcal
1 kWh of electricity = 860 kcal
Source MoR (2000a)

In terms of gross tonne-km, electric and diesel traction hauls 59.4% of the freight traffic. Of passenger services, 99.9% is operated by diesel or electric locomotives and only 0.1% by steam (MoR 2000b). The energy consumed by diesel and electric traction in 1996/97 is given in Table VI.

Policy developments

The focus of the Ninth Five-year Plan is on strengthening the capacity of the Indian railway system as a prime carrier of long-distance bulk freight and passenger traffic. To achieve this objective, the Railways is focusing on the following policy options.

Augmentation of high-density corridors

The transport system is characterized by a system of HDCs (high-density corridors) linking major urban areas. Augmentation of capacity of the HDC system continues to receive high priority. Upgradation of passenger and freight terminals is also necessary to augment the capacity on the busy sections of the Indian Railways, leading to the generation of adequate rail capacity for handling the increasing freight and passenger traffic, with special emphasis on the development of terminals.

Reducing speed differentials

The Railways is focusing on reducing the speed differentials between freight and passenger services by raising the speed of freight cars. This will improve the traffic throughput in the system.

Upgradation of locomotive technology

Railways is in the process of modernization and upgradation of the rail transport system. Locomotive technology is being improved by adopting the latest locomotives, as well as upgrading the existing fleet through retrofitment. Mechanization of track maintenance is another high-priority area. This will reduce costs, improve reliability, safety, and quality of service to customers. New wagons fit for high speeds (100 km/h) have also been procured. These wagons have considerably reduced transit time and improved quality of service to customers.

Encourage multimodal transport

To promote intermodalism for safe, efficient, customer-friendly, and faster movement of goods, the focus is on increasing inland container depots. The strategy is to create rail hubs with sufficient warehousing facilities and accelerate the programme of containerization, not only to promote intermodal transport, but also to increase its market share and cater to high-value traffic.

Increase carriage of high-rated non-core piecemeal traffic

Railways are basically carriers of bulk commodities such as coal, iron ore, cement, fertilizers, foodgrains, and POL (petroleum, oil, and lubricants), etc. However, to increase the carriage of high-rated non-core piecemeal traffic, the Indian Railways has evolved the following marketing strategies.

- Leasing brake vans in mail/express and passenger trains to get assured traffic at a high rate
- Clearing modified traffic in modified vans
- Leasing parcel vans to clear valuable parcel traffic with significant freight potential
- Containerizing 'wagon load' and 'less than wagon load' traffic.

Privatization

Railways is now moving towards privatization of associated and supporting services such as catering services and maintenance of platforms and stations. They have also encouraged the formation of joint ventures to implement financially viable projects through public/private participation, especially for strengthening basic infrastructure in the area of line capacity, augmentation, rail connectivity to new private ports, and development of private terminals.

Other than this, the Railways has decided on the leverage of huge assets, such as right of way, surplus land, and air space, for generating additional resources.

Draft approach paper: Tenth Five-year Plan

The approach to Tenth Five-year Plan is to gradually cut the cross-subsidization of passenger fares from freight. They have also recommended the establishment of an independent Rail Tariff Regulatory Authority. Emphasis has to be given to all ongoing projects by ensuring adequate resources. Capacity is to be improved on the Golden Quadrilateral by undertaking doubling, opening up of alternative routes through new lines, gauge conversion, etc.

Another target of the Tenth Plan is to enlarge the scope of private sector participation in acquiring the rolling stock through innovative mechanisms (Planning Commission 2001).

Civil aviation

Civil aviation consumes less than one per cent of the total energy consumption by the transport sector; therefore, the policy interventions related to energy consumption are not significant. To meet the growing travel demand, upgradation and improvement of airport infrastructure and capacity augmentation have been the major thrust areas for the Department of Civil Aviation. At present, there are 449 airports/airstrips in the country. Among these, the AAI (Airports Authority of India) owns and manages 5 international airports, 87 domestic airports, and 28 civil enclaves at defence airfields and provides air traffic services over the entire Indian airspace and adjoining oceanic areas. In 1998/99, these 120 airports/civil enclaves handled 0.42 million aircraft movements involving 24.17 million domestic and 12.83 million international passengers and 0.22 MT of domestic and 0.47 MT of international cargo. 51% of the traffic was handled at the international airports at Mumbai and Delhi. Presently, various airlines are operating only through 61 airports. The remaining are lying unutilized, at best handling occasional aircraft operations. The turnover of the AAI was 15.91 billion rupees for the year that ended March 1999.

The reforms in this sector have been to strengthen the institutional and regulatory framework so as to ensure safety and security. Private sector participation is also very essential to ensure large investments for proper provision and maintenance of the airport infrastructure. Therefore, the Government of India, in line with its policy of liberalization, decided to corporatize Chennai, Delhi, Kolkata, and Mumbai airports in order to attract the much-needed capital for expansion and modernization of these airports to world-class standards.

Also, the government has decided to set up a parallel cargo terminal at the Indira Gandhi International Airport by way of a joint venture between the AAI and the private sector, in order to offer an option to users so as to achieve better services and increased efficiency through healthy competition.

Ports

India has a 7516.6-km-long coastline (including 1962 km of Andaman and Nicobar Islands), has 12 major ports (of which 11 are operational and the 12th is under construction), and 148 minor ports. The traffic handled by the major and minor ports during the last five years is given in Table VII.

During 1999/2000, approximately 81% (272 MT) of the total traffic was handled by the major ports, as against the total capacity of 258 MT. During the same period, the total cargo movement was about eight per cent more than the previous year. This implies that there is a need to augment the port capacity. A long-term plan for the port sector for the year 2020 is under finalization.

Table VII Traffic handled by major and minor ports (million tonnes)

Ports	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Major ports	215.34	227.13	251.44	251.70	271.92
Minor ports	20.30	24.93	26.13	35.66	62.35
Total	235.64	252.06	277.57	287.36	334.27
Share of major ports (%)	91	92	91	88	81
Share of minor ports (%)	9	8	9	12	19

Source MoST (2000)

Policy development

The Government of India has taken policy initiatives to improve exports by restructuring the ports. Accordingly, in October 1996, policy guidelines were issued, which provided for private sector participation/investment in the following areas.

- Leasing out existing assets of the port
- Creating additional assets such as
    - construction and operation of container terminals
    - construction and operation of bulk, multipurpose, and specialized cargo berths
    - warehousing, container freight stations, storage facilities, and tank farms
    - cranage/handling equipment
    - setting up of captive power plants
    - dry-docking and ship repair facilities
- Leasing of equipment for port handling and leasing of floating crafts from the private sector
- Captive facilities for port-based industries.

Draft approach paper: Tenth Five-year Plan

The major target of the Tenth Plan is to corporatize the major ports within a short period of time, induce private sector investments, and to achieve a capacity of 11–15 MT through productivity improvement during the plan period (Planning Commission 2001).

Coastal shipping

The share of coastal shipping has increased from 0.2 million GRT (gross revenue per tonne) in 1971, to 0.6 million GRT in 1998. Presently, the cargo moved by coastal shipping comprises coal, clinker, cement, crude oil, POL, and iron ore. Over the years, the general cargo, which is an important component of coastal trade, has been weaned away by other modes of transport. The development of coastal shipping has been slow despite the entire coastal trade being reserved for Indian vessels. The problems and issues constraining for the development of this sector are as follows.

- Coastal ships are subjected to an unnecessarily high cost structure due to their compliance with the same standards as those for ocean-going vessels. They compete with overseas vessels for the same port space and high manning scales at par with overseas shipping.

- Complicated customs procedures applicable to international trade are applied even to coastal movements, causing delays and increasing costs (MoST 1999).

Due to these impediments, ship owners are reluctant to acquire dedicated coastal vessels, thus leading to obsolete technology and lack of skilled labour and manpower to manage coastal shipping. This has led to coastal shipping not being regarded as a lucrative field for investment as compared with other shipping enterprises, leading to its stunted growth.

Policy developments

The development of coastal shipping in the country warrants that it be accorded a status on par with other modes of domestic transport. Recognition of coastal shipping as an infrastructure industry has been recommended in various fora. Therefore, a package that includes the creation of infrastructure facilities, simplification of customs procedure, and fiscal incentives for development of coastal shipping is essential to remove the various impediments hampering the growth of coastal shipping. The government has taken measures to develop coastal shipping. The present policy of the government is to take necessary legislative and fiscal measures for its development. The major policy developments initiated by the Ministry of Shipping are given below.

- Create separate berth facilities and additional infrastructure at ports for coastal shipping
- Exempt vehicles carrying coastal goods from sections of the customs act so as to reduce the customs procedures for coastal shipping, and also reducing the charges and thus the total cost.

Upgradation of port infrastructure will involve huge investments, requiring support from the private sector. The government's efforts will be supplemented by the efforts of the private sector. Guidelines have been laid down for private sector participation in the port sector.

The shipping industry is conscious about conservation of energy and has been looking at ways and means to achieve this. Fuel oil is the main energy source for ships. The industry has been trying to replace its old vessels with those having new hull designs, self-polishing paints, and other improvements in the propeller machinery, which help reduce resistance, thereby giving more speed per horsepower to the ships (MoST 2000b).

Table VIII Energy consumed by various modes of transport

Mode	*Energy consumed* (kcal per 1000 gross tonne-km)
Diesel train	30 039
Electric traction	7 654
Diesel bus/truck	403 193
Barge	83 159

Source Inland Waterways Authority of India (1999)

Inland water transport

Inland water transport (IWT) is the most efficient mode of transportation from the point of energy consumption, lower cost of transportation, and environment friendliness. Notwithstanding these advantages, IWT in India has gradually declined due to various reasons, the lack of investment for creating infrastructural facilities being the major contributory factor. The energy consumed by various modes of transport is given in the Table VIII.

The energy consumed by IWT is more compared with electric traction, but less than what is consumed by road transport. It also has the advantage of having low capital cost of infrastructure development since the basic right of way is the river channel.

However, at present, IWT forms a very small part of the total transport network. In terms of tonne per kilometres, its share is less than one per cent. The freight carried by IWT has declined from 2.42 MT in 1993/94 to 1.88 MT in 1996/97. The main reason for the small share of IWT is its spatial limitations. Besides, most of the waterways suffer from navigational hazards such as shallow water and narrow width of channel during dry weather, siltation, bank erosion, absence of terminal infrastructural facilities, and inadequacy of navigational aids. There is a need to remove the constraints faced by these modes of transport so that they become more viable alternatives to surface modes.

The north-eastern region offers immense potential for the development of IWT as a cheap, viable, and eco-friendly mode of transportation for various commodities through Bangladesh. IWT offers a bright scope for evolving an intermodal approach in its development.

The Indo-Bangladesh protocol on inland water transit and trade is valid till October 2001. The principal activities of this agreement are as follows.

- Transportation of cargo through inland waterways
- Construction and repair of IWT vessels
- Repair of ocean-going vessels
- General engineering work.

The two governments agreed to share the inter-country trade and transit cargo on an equal tonnage basis by the vessels of signatory countries to and from ports of call, including extended places of loading and unloading under customs formalities and supervision.

Policy developments

Recognizing the constraints faced by IWT and its potential for growth, the thrust is on making IWT an acceptable mode of transportation. The basic requirements identified are the reduction in cost and time of transportation and enhancement of safety and reliability.

There is an opportunity now to link the inland waterways with ports, particularly minor and intermediate ports, so that cargoes emanating from the hinterland can be transported directly to the ports through inland waterways without any diversion to roads. Such a programme will benefit both the shipping and the IWT sectors, and if combined with an attractive incentive system, large investment from the private sector can be infused, as the assured cargo traffic will make the package commercially profitable.

To give priority to the development of IWT in India, the Government of India decided to give a major thrust to the development of waterways. In pursuit of this policy, the following three waterways have been declared as national waterways.

- *National Waterway No. 1 (1620 km)* The Ganga–Bhagirathi–Hooghly river system connecting Haldia, Kolkata, Farakka, Semeria, Patna, Varanasi, and Allahabad
- *National Waterway No. 2 (891 km)* The Brahmaputra river connecting Dhubri, Guwahati, Tezpur, Dibrugarh, and Sadiya
- *National Waterway No. 3 (205 km)* The West Coast Canal system stretching from Kottapuram to Kollam, Champakkara canal, and Udyogmandal canal.

In addition, the National Transport Policy Committee has identified 10 more waterways that can be declared as national waterways.

- The Ganga–Bhagirathi–Hoogly river system
- The Brahmaputra
- The West Coast Canal
- The Sunderbans
- The Godavari
- The Krishna
- The Mahanadi
- The Narmada
- The Mandovi, Zuari rivers and Cumberjua Canal in Goa.
- The Tapi

Multimodal transport

Multimodal transport has emerged as one of the important forms of transportation of goods. Containerization has helped in developing multimodal transport. It is an effective, efficient, and safe means of transporting goods, combining roads, railways, and ports. Multimodalism is recognized the world over as a vital national and international requirement. It is particularly significant for India domestically, because of the vast size of the country and interdependence of different areas and regions for agricultural, consumer, and industrial goods, and internationally due to the emerging trend of globalization. Each mode of transport has its own role to play in an integrated multimodal transport system. Although railways are energy efficient, they cannot reach every part of the country. Roads have a distinctive role to play in such cases, as they offer a door-to-door service. Therefore, to encourage water transport, there is a need to integrate the IWT system with coastal shipping, including its easy linkages with the ports.

Road transport consumes maximum energy in the transport sector. Therefore, as far as possible, if the goods are transported by the railways (which is a more energy-efficient mode) and IWT (where transportation by railways is not possible), the total energy consumed in transporting goods from one destination to another will be comparatively less.

The government promulgated the Multimodal Transport Act in 1993. However, multimodal transport still faces certain problems (listed below) that prevent its growth and development (MoCA 1999).

- Complex procedures and excessive paperwork make it difficult to tranship goods from one mode to another mode within the country.

- Lack of coordination between various government departments leads to the issue of segment transport receipts for each mode instead of provision of a combined transport document as per the provisions of the Act.
- Air transport is still not recognized as a multimodal transport in the Act.
- There are a limited number of inland container depots; the few that exist are concentrated around Bangalore, Chennai, and Mumbai.

The need to promote containerization has been spelt out in various policy documents. While containerization has been increasingly adopted the world over, the process has been slow in India. CONCOR (Container Corporation of India) Ltd provides multimodal containerized cargo handling and transport services. From about 155 000 TEUs (twenty-feet equivalent units) handled in 1992/93, the traffic throughput has reached 722 000 TEUs, an almost five-fold increase in five years (CONCOR 1998).

The Railways has identified multimodal transport as a technique to recapture its share in the general cargo traffic that it lost to the road sector (MoR 1993). The Railways can become the principal partner and a multimodal transport operator or just provide haulage on the rail portion. The efforts of the Railways in this regard have focused on raising the container traffic handled by CONCOR.

References

Bose R K. 1998
Automotive energy use and emissions control: a simulation model to analyse transport strategies for Indian metropolises
Energy Policy 26(13): 1001–1016

Bose R K, Sundar S, and Nesamani K S (eds). 2000
Clearing the Air: better vehicles, better fuels
New Delhi: Tata Energy Research Institute. 345 pp.

CONCAWE. 1999
Potential of exhaust after treatment and engine technologies to meet future emissions limits: conservation of clean air and water in Europe
Brussels: CONCAWE [Report no. 99/55]

CONCOR (Container Corporation of India Ltd). 1998
Annual Report 1997/98
New Delhi: CONCOR

CPCB (Central Pollution Control Board). 1999
Auto emissions
Parivesh Newsletter 6(1): 1–16

CPCB (Central Pollution Control Board). 2000
Air quality status and trends in India
New Delhi: CPCB, Ministry of Environment and Forests

CPCB (Central Pollution Control Board). 2001
Fuel quality: 2005
New Delhi: CPCB

CSO (Central Statistical Organization). 2000
National accounts statistics
New Delhi: CSO, Ministry of Planning and Programme Implementation

IIP (Indian Institute of Petroleum). 1994
Vehicle emissions and control perspectives in India: a state of the art report
Dehra Dun: IIP.

Inland Waterways Authority of India. 1999
Annual Report 1997/98
New Delhi: Inland Waterways Authority of India

MoCA (Ministry of Civil Aviation). 1999
Report of the expert committee on an integrated approach to the movement of goods in international trade
New Delhi: MoCA, Government of India

MoF (Ministry of Finance). 2001
Economic Survey 2000/2001
New Delhi: MoF, Government of India.

MoPNG (Ministry of Petroleum and Natural Gas). 2001
Indian Petroleum and Natural Gas Statistics 1999/2000
New Delhi: MoPNG, Economic and Statistics Division, Government of India.

MoR (Ministry of Railways). 1993
Railway Board: railway fare and freight structure committee report
New Delhi: MoR, Government of India

MoR (Ministry of Railways). 2000a
Indian Railways Annual Statistical Statements 1998/99
New Delhi: MoR, Government of India

MoR (Ministry of Railways). 2000b
Indian Railways Yearbook 1998/99
New Delhi: MoR, Government of India.

MoST (Ministry of Surface Transport). 1996
Report of the working group on road transport for the Ninth Five-year Plan (1997–2002)
New Delhi: MoST

MoST (Ministry of Surface Transport). 1999
Indian Shipping Statistics 1998
New Delhi: Transport Research Wing, MoST, Government of India

MoST (Ministry of Surface Transport). 2000
Basic Port Statistics 1999/2000
New Delhi: MoST, Transport Research Wing, Government of India.

MoST (Ministry of Surface Transport). 2000a
Handbook of Transport Statistics 1998/99
New Delhi: MoST, Transport Research Wing, Government of India.

MoST (Ministry of Surface Transport). 2000b
Annual Report 1998/99
New Delhi: MoST, Government of India.

Planning Commission. 1980
Report of the National Transport Policy Committee
New Delhi: Planning Commission, Government of India

Planning Commission. 2001
Draft approach paper to the Tenth Five-Year Plan (2002–2007)
New Delhi: Planning Commission, Government of India

SIAM (Society of Indian Automobile Manufacturers). 2000
Auto industry rolls out future emission norms for India
Viewpoint: A Quarterly Newsletter of the SIAM **II**(1): 2–4

Table 2.56 GDP (Gross domestic product) in the transport sector (**million rupees**): 1980/81 to 1997/98

Item	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*[a]	*1994/95*	*1995/96*	*1996/97*	*1997/98*
At current prices										
Railways	11 240	31 360	64 330	73 420	84 460	96 480	112 030	125 800	132 560	144 470
Road transport	24 540	69 020	177 900	222 260	262 670	227 590	266 600	305 920	373 900	444 320
Water transport	8 230	11 910	23 780	27 320	32 240	53 610	64 290	76 450	84 840	92 470
Air transport	2 550	5 880	10 650	12 390	15 800	17 270	21 800	25 240	28 740	39 880
Total	46 560	118 170	276 660	335 390	395 170	394 950	464 720	533 410	620 040	721 140
GDP (%)	3.80	5.05	5.80	6.10	6.30	6.50	6.70	6.60	6.70	7.10
At constant prices										
Railways	11 240	14 040	16 770	17 780	17 580	96 480	98 460	106 570	111 690	113 680
Road transport	24 540	38 610	59 980	63 580	66 890	227 590	248 040	270 440	293 840	311 980
Water transport	8 230	8 430	10 900	11 330	11 910	53 610	58 750	63 400	66 010	67 940
Air transport	2 550	3 610	3 850	3 840	3 590	17 270	21 380	24 870	23 420	26 420
Total	46 560	64 690	91 500	96 530	99 970	394 950	426 630	465 280	494 960	520 020
GDP (%)	3.80	4.13	4.31	4.50	4.40	6.50	6.70	6.90	7.00	7.30

[a] from 1993/94 onwards, the estimates are at 1993/94 prices

Source

CSO. ***National Accounts Statistics*** (various issues). New Delhi: Central Statistical Organization, Department of Statistics, Ministry of Planning and Programme Implementation.

For more details, please see TEDDY ONLINE+ [Section: Transport (general)]

Table 2.57 Petroleum, oil, and lubricants consumption (**thousand tonnes**) in transport: 1990/91 to 1999/2000

Sector	*1990/91*	*1992/93*	*1994/95*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]
High-speed diesel							
Road Transport	1 864	2 057	2 156	2 224	2 433	2 350	2 409
Aviation	11	12	6	6	8	19	33
Shipping	193	183	207	240	211	219	262
Railways	1 453	1 417	1 398	1 498	1 401	1 419	1 380
Other transport[b]	15 292	18 057	20 975	26 389	27 053	28 091	29 615
Light diesel oil (regular)							
Road Transport	1	1	1	2	2	2	3
Aviation	1	1	1	1	1	1	4
Shipping	67	66	62	46	41	45	43
Railways	4	2	2	2	4	2	2
Other transport[b]	13	15	17	15	16	13	7
Fuel Oil							
Road Transport	45	7	8	8	9	8	6
Aviation	4	5	3	3	2	2	22
Shipping	300	235	323	249	214	251	209
Railways	22	15	13	12	12	11	11
Other transport[b]	76	77	93	79	78	77	103

[a] provisional

[b] Including agricultural retail trade

Source

MoPNG. 2001. ***Indian Petroleum and Natural Gas Statistics*** (various issues).
New Delhi: Economic and Statistics Division, Ministry of Petroleum and Natural Gas.

Table 2.58 Key data on transport: 1970/71 to 1999/2000

Parameter	Unit	*1970/71*	*1980/81*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Railways													
Gross revenue receipts	Million rupees	10 070	27 035	124 516	141 137	161 147	183 633	205 291	228 138	248 013	291 342	302 340	338 557
Route / length	Km	59 790	61 240	62 367	62 458	62 486	62 462	62 660	62 915	62 725	62 495	62 809	62 759
Electrified	Km	3 706	5 345	9 968	10 653	11 064	11 260	11 772	12 306	13 018	13 490	13 765	14 261
Stations	No.	7 066	7 035	7 100	7 116	7 043	7 050	7 056	7 068	6 984	6 929	6 896	6 867
Locomotives	No.	11 158	10 908	8 417	8 268	7 806	7 220	6 919	6 909	6 975	7 206	7 429	7 517
Steam	No.	9 387	7 469	2 915	2 492	1 725	911	358	209	85	64	58	56
Diesel	No.	1 169	2 403	3 759	3 905	4 069	4 192	4 259	4 313	4 363	4 496	4 586	4 651
Electric	No.	602	1 036	1 743	1 871	2 012	2 117	2 302	2 387	2 527	2 646	2 785	2 810
Passenger coaches	No.	35 145	38 333	38 511	39 350	39 924	40 053	39 214	38 881	39 308	40 166	40 988	41 348
Electric multiple-unit coaches	No.	1 750	2 625	3 142	3 366	3 444	3 537	3 618	3 691	3 846	3 971	4 076	4 188
Wagons	Thousand	384	401	346	346	338	312	291	281	272	264	253	244
Number of employees	Thousand	1 374	1 572	1 652	1 654	1 646	1 625	1 602	1 587	1 584	1 579	1 578	1 577
Average wage per employee	Rupees	3 398	8 435	31 864	35 528	40 466	45 709	50 777	59 116	66 645	89 669	98 783	102 946
Passengers carried	Million	2 431	3 613	3 858	4 049	3 749	3 708	3 915	4 018	4 153	4 348	4 411	4 585
Suburban passengers	Million	1 219	2 000	2 259	2 412	2 282	2 302	2 430	2 484	2 578	2 658	2 668	2 771
Non-suburban passengers	Million	1 212	1 613	1 599	1 637	1 467	1 406	1 485	1 534	1 575	1 691	1 743	1 814
Passenger-km	Billion	118	209	296	315	300	296	319	342	357	380	404	431
Revenue-earning goods traffic	Tonne	168	196	318	338	350	359	365	391	409	429	421	456
Net tonne-km	Million	127	158	243	257	258	257	253	274	280	287	284	308
Revenue-earning traffic	Million	111	148	236	250	252	252	250	270	278	284	282	305
Road													
Road length	Thousand km	918	1 485	2 350	2 486	2 679	2 955	3 059	3 283	2 466	–	–	–
Surfaced	Thousand km	398	684	1 113	1 160	1 283	1 341	1 216	1 334	1 394	–	–	–
Unsurfaced	Thousand km	520	802	1 238	1 326	1 433	1 578	1 636	1 070	1 072	–	–	–
Motor vehicles registered	Thousand	1 865	5 391	21 374	23 507	25 505	27 660	30 295	33 783	37 231	–	–	–

Ports													
Major ports	No	10	10	11	11	11	11	11	11	11	11	11	11
Cargo handled at major ports	Million tonnes	56	80	152	157	166	178	197	215	227	252	252	272
Merchant shipping tonnage	Thousand	901	2 500	6 027	5 939	6 267	6 329[a]	6 900[b]	7 020	–	–	–	–
Air traffic													
Indian Airlines													
Revenue passengers	Million	2	5	8	9	8	8	8	8	8	8	8	8
Revenue tonne-km	Million	200	400	699	761	685	695	686	723	765	828	841	871

[a] as on 30 November 1994

[b] as at the end of October

Sources

1 MoR. ***Annual Report and Accounts*** (various issues). New Delhi: Ministry of Railways.

2 MoF. ***Economic Survey*** (various issues). New Delhi: Economic Division, Ministry of Finance.

3 MoST. ***Handbook of Management Information*** (various issues). New Delhi: Transport Research Wing, Ministry of Surface Transport.

4 MoST. 2001. ***Motor Transport Statistics of India 1997/98***. New Delhi: Transport Research Wing, Ministry of Surface Transport.

5 MoR. 1999. ***Indian Railways Year Book 1998/99***. New Delhi: Ministry of Railways.

For more details, please see TEDDY ONLINE+ [Section: Transport (general)]

Table 2.59 Registered motor vehicles (**thousands**): 1975 to 1998

Category	*1975*	*1980*	*1985*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
Two-wheelers	946	2 117	5 179	12 611	14 200	15 661	17 183	18 899	20 831	23 252	25 693	28 342
Cars, jeeps, and taxis	766	1 059	1 607	2 694	2 954	3 205	3 361	3 569	3 841	4 204	4 662	5 056
Buses	114	140	223	298	331	358	364	392	423	449	488	535[a]
Goods vehicles	335	473	822	1 238	1 356	1 514	1 603	1 691	1 794	2 031	2 260	2 529
Others[b]	311	732	1 339	2 311	2 533	2 769	2 994	3 109	3 406	3 847	4 128	4 477
All vehicles	2 472	4 521	9 170	19 152	21 374	23 507	25 505	27 660	30 295	33 783	37 231	40 939

[a] includes omnibuses

[b] include tractors, trailers, three-wheelers (passenger and goods vehicles and other miscellaneous vehicles which are not separately classified)

Note

Figures pertain to 31 March of respective years.

Source

MoST. 2001. ***Motor Transport Statistics of India, 1997/98***. p. 1. New Delhi: Transport Research Wing, Ministry of Surface Transport. (For statistics beyond 1992.)

Table 2.60 Registered taxed and tax-exempted motor vehicles (numbers) in metropolitan cities: 1997/98

City	All vehicles	Two-wheelers	Three-wheelers		Cars	Jeeps	Taxis	Buses	Trucks	Tractors	Trailers	Others
			Passenger	Goods								
Ahmedabad	686 227	529 814	36 299	7 951	75 572	7 069	4 167	14 574	9 122	103	164	520
Bangalore	1 129 836	839 072	54 066	20 119	152 004	6 497	8 123	16 035	12 708	5 006	4 510	3 001
Bhopal	237 293	187 745	7 847	2 777	14 601	3 777	3 140	2 169	3 986	7 724	2 876	551
Chennai	975 009	712 831	36 132	4 940	169 706	7 007	8 060	3 787	22 142	1 136	–	7 496
Coimbatore	309 872	240 968	6 027	1 169	37 694	3 056	2 276	1 204	10 450	5 515	–	816
Delhi	3 033 045	1 991 710	80 210	–	765 470	–	16 654	32 333	146 668	–	–	–
Hyderabad	887 367	711 977	41 588	15 093	75 059	14 838	2 692	2 619	18 792	214	261	575
Indore	399 096	296 766	9 319	5 463	36 065	4 142	6 088	3 487	22 289	8 252	5 830	1 395
Jaipur	492 020	364 530	6 875	164	43 874	15 929	3 942	13 202	22 153	16 854	2 669	320
Kanpur	281 874	230 428	4 193	2 407	25 564	3 178	644	699	23 661	1 365	401	2 062
Kochi	–	–	–	–	–	–	–	–	–	–	–	–
Kolkata	664 046	298 959	9 747	–	238 560	–	32 199	8 586	59 576	4 736	–	11 683
Lucknow	359 722	285 511	8 073	2 963	31 847	9 607	2 767	1 856	5 465	8 340	832	2 400
Ludhiana	–	–	–	–	–	–	–	–	–	–	–	–
Madurai	155 621	127 506	4 501	1 887	8 392	502	1 881	1 083	5 844	3 338	–	523
Mumbai	859 734	354 799	83 705	29 380	273 581	21 274	51 959	14 389	19 541	1 225	1 151	4 700
Nagpur	273 994	217 065	9 784	6 467	16 341	5 712	1 274	2 487	8 140	292	494	315
Patna	244 859	166 500	13 215	–	22 920	10 676	–	–	13 695	5 699	4 926	827
Pune	526 635	391 797	37 849	10 106	43 852	8 937	3 388	9 820	18 351	622	597	738
Surat	398 648	338 146	18 201	3 201	32 022	2 527	688	641	2 246	123	176	340
Vadodara	361 117	272 887	19 258	9 808	38 432	5 638	3 333	2 312	5 446	1 308	2 305	390
Varanasi	198 662	154 479	6 582	1 766	10 273	5 885	899	2 250	7 147	7 830	767	782
Visakhapatnam	219 239	190 546	1 527	456	12 628	2 027	2 386	119	7 965	137	699	733

Source

MoST. 2001. ***Motor Transport Statistics of India, 1997/98***. p. 75–86. New Delhi: Transport Research Wing, Ministry of Surface Transport.

For more details, please see TEDDY ONLINE+ [Section: Transport (road transport)]

Table 2.61 Buses owned (thousands) by public and private sectors: 1975 to 1998

Category	*1975*	*1980*	*1985*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
Public sector[a]	50.4	65.4	80.2	102.3	106.1	106.9	109.5	109.7	110.3	111.1	111.0	113.8
Private sector	63.2	74.9	143.0	195.7	225.0	251.3	271.5	309.1	314.6	338.7	377.1	421.2
Total	113.6	140.3	223.2	298.0	331.1	358.2	381.0	418.8	424.9	449.8	488.1	535.0
Nationalization (%)	44.4	46.6	35.9	34.3	32.0	29.8	28.7	26.2	26.0	24.7	22.7	21.3

[a] held by state road transport undertakings

Note

Figures pertain to 31 March of respective years.

Source

MoST. 2001. ***Motor Transport Statistics of India, 1997/98.*** p. 6. New Delhi: Transport Research Wing, Ministry of Surface Transport.

For more details, please see TEDDY ONLINE+ [Section: Transport (road transport)]

Table 2.62 Road length (km) by category: 1991 to 1997

Highways	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
Highways	1 601 684	1 619 804	1 697 291	1 718 172	1 743 183	1 908 469	1 993 764
Maintained by the PWD (Public Works Department)	670 396	683 316	659 628	667 265	679 393	886 662	940 225
National highways	33 650	33 666	33 916	34 249	34 262	34 508	34 849
State highways	127 311	128 622	129 876	132 401	134 085	135 187	137 119
Other/PWD roads	509 435	521 028	495 836	500 615	511 046	716 967	768 257
Panchayat roads	931 288	936 288	1 037 663	1 048 907	1 063 790	1 021 807	1 053 539
Urban roads	186 799	189 352	195 150	202 013	204 577	212 920	232 234
Project roads	209 737	212 485	222 057	224 606	225 481	245 673	239 879
Total[a]	2 327 382	2 462 289	2 678 843	2 955 231	3 059 317	3 283 072	2 465 877[b]

[a] including road lengths constructed under Jawahar Rozgar Yojana

[b] excluding Jawahar Rozgar Yojna roads

Source

MoST. ***Handbook of Management Information*** (various issues). New Delhi: Transport Research Wing, Ministry of Surface Transport.

For more details, please see TEDDY ONLINE+ [Section: Transport (road transport)]

Table 2.63 Total and surfaced length (km) of national highways (as on 31 March): 1991 to 1997

	1991		*1994*		*1996*		*1997*	
State / Union Territory	*Total*	*Surfaced*	*Total*	*Surfaced*	*Total*	*Surfaced*	*Total*	*Surfaced*
State								
Andhra Pradesh	2 587	2 556	2 949	2 918	2 949	2 918	2 949	2 918
Arunachal Pradesh	368	271	368	271	368	271	368	271
Assam	2 227	2 227	3 354	2 253	2 254	2 253	2 254	2 253
Bihar	2 118	2 118	2 118	2 118	2 218	2 218	2 218	2 218
Goa[a]	225	225	225	225	225	225	225	225
Gujarat	1 572	1 572	1 570	1 570	1 570	1 570	1 570	1 570
Haryana	655	655	656	656	656	656	656	656
Himachal Pradesh	722	718	728	723	732	727	733	733
Jammu and Kashmir	648	648	648	648	648	648	648	648
Karnataka	1 997	1 997	1 997	1 997	1 997	1 997	1 997	1 997
Kerala	817[b]	817[b]	1 011	1 011	1 011	1 011	1 011	1 011
Madhya Pradesh	2 976	2 976	2 976	2 976	2 976	2 976	2 976	2 976
Maharashtra	2 949	2 901	2 953	2 905	2 958	2 910	2 958	2 910
Manipur	434	434	434[b]	434[b]	438	438	438	438
Meghalaya	462	462	454	454	464	464	464	464
Mizoram	571	571	566	566	566	566	566	566
Nagaland	113	113	113	113	113	113	113	113
Orissa	1 624	1 553	1 624	1 624	1 625	1 590	1 625	1 590
Punjab	968[b]	968[b]	988	988	988	988	1 198	1 198
Rajasthan	2 840	2 840	2 846	2 846	2 846	2 846	2 846	2 846
Sikkim	41	41	53	53	53	53	53	53
Tamil Nadu	2 002	2 002	2 002	2 002	2 002	2 002	2 002	2 002
Tripura	195	195	198	198	198	198	198	198
Uttar Pradesh	2 754	2 754	2 733	2 733	2 862	2 862	2 883	2 883
West Bengal	1 651	1 651	1 651	1 651	1 651	1 651	1 715	1 715
Union Territory								
Andaman and Nicobar Islands	–	–	–	–	–	–	–	–
Chandigarh	34	34	34	34	34	34	64	64
Dadra and Nagar Haveli	–	–	–	–	–	–	–	–
Delhi	75	75	75	75	75	75	75	75
Lakshadweep	–	–	–	–	–	–	–	–
Pondicherry	25	25	25	25	31	31	46	46
All-India	33 650	33 399	33 249	34 033	34 508	34 291	34 849	34 637

[a] includes data for Daman and Diu

[b] for 1989/90

Source

MoST. ***Handbook of Management Information*** (various issues). New Delhi: Transport Research Wing, Ministry of Surface Transport.

Table 2.64 Road length in relation to area and population in states and union territories: 31 March 1997

State / Union Territory	*Total road length* (km)	*Area* (km²)	*Population: as on 1 July 1997* (million)[a]	*Road length* (km) *Per hundred km² of area*	*Road length* (km) *Per million of population*
State					
Andhra Pradesh	178 012	275 068	7 340	64.7	2 425
Arunachal Pradesh	14 092	83 743	110	16.8	12 811
Assam	68 418	78 438	2 530	87.2	2 704
Bihar	88 352	173 877	9 520	50.8	928
Goa	8 563	3 814	150	224.5	5 709
Gujarat	90 896	196 024	4 640	46.4	1 959
Haryana	28 164	44 212	1 800	63.7	1 565
Himachal Pradesh	30 193	55 673	620	54.2	4 870
Jammu and Kashmir	21 446	222 236	930	9.7	2 306
Karnataka	144 012	191 791	5 030	75.1	2 863
Kerala	145 704	38 863	3 150	374.9	4 626
Madhya Pradesh	200 137	443 446	7 600	45.1	2 633
Maharashtra	361 893	307 690	8 830	117.6	4 098
Manipur	10 941	22 327	230	49.0	4 757
Meghalaya	8 480	22 429	220	37.8	3 855
Mizoram	4 829	21 081	90	22.9	5 366
Nagaland	18 356	16 579	150	110.7	12 237
Orissa	262 703	155 707	3 490	168.7	7 527
Punjab	64 352	50 362	2 380	127.8	2 704
Rajasthan	129 674	342 239	5 100	37.9	2 543
Sikkim	1 834	7 096	50	25.8	3 668
Tamil Nadu	206 503	130 058	6 030	158.8	3 425
Tripura	14 729	10 486	340	140.5	4 332
Uttar Pradesh	255 467	294 411	16 070	86.8	1 590
West Bengal	75 435	88 752	7 610	85.0	991
Union Territory					
Andaman and Nicobar Islands	1 317	8 249	40	16.0	3 593
Chandigarh	1 753	114	80	1 537.7	2 191
Dadra and Nagar Haveli	533	491	20	108.6	2 665
Delhi	26 582	1 483	1 250	1 792.4	2 127
Daman and Diu	101	3 814	10	2.6	1 010
Lakshadweep	1	32	10	3.1	10
Pondicherry	2 405	495	100	485.9	2 405
All-India[b]	2 465 877	3 291 080	95 520	74.9	2 582

[a] estimated mid-year population by Registrar General of India, Ministry of Home Affairs

[b] excluding Jawahar Rozgar Yojna roads

Source

MoST. ***Handbook of Management Information*** (various issues). New Delhi: Transport Research Wing, Ministry of Surface Transport.

Table 2.65 Status of BOT (build-operate-transfer) projects awarded as on 25 November 1998

Name of the project	National Highway number	State	Length/ number	Cost (million rupees)	Date of signing	Date of completion	Agency	Current status
Thane-Bhiwandi Bypass	3 and 4	Maharashtra	24	1030.0	12 September 1995	31 December 2001	MRTH	In progress
Chaltan ROB (road over bridge)[a]	8	Gujarat	4 Lane	100.0	19 September 1996	15 July 1998	MRTH	Completed
Udaipur Bypass[a]	8	Rajasthan	11 km	240.0	July 1996	22 April 1998	MRTH	Completed
Construction of six bridges	5	Andhra Pradesh	6	50.0	9 April 1997	8 June 2001	MRTH	In progress
Coimbatore Bypass	47	Tamil Nadu	33 km	900.0	30 October 1997	3 December 1999	MRTH	In progress
Durg Bypass	6	Madhya Pradesh	18.4 km	680.0	5 November 1997	5 May 2000	NHAI	In progress
Narmada Bridge	8	Gujarat	6	1130.0	21 November 1997	21 December 2000	MRTH	In progress
Nardhana ROB	3	Maharashtra	13 km	342.0	25 November 1997	22 July 1999	MRTH	Completed
Patalganga Bridge	17	Maharashtra	1	333.0	29 November 1997	20 July 2000	MRTH	Completed
Hubli-Dharwar Bypass	4	Karnataka	30.35 km	680.0	5 February 1998	5 November 2001	MRTH	In progress
Nellore Bypass	5	Andhra Pradesh	18 km	730.0	17 February 1998	17 February 2001	NHAI	Concession, agreement, signed
Koratalaiyar Bridge	5	Tamil Nadu	–	300.0	28 October 1998	October 2000	MRTH	In progress
Khambatki Ghat Tunnel	4	Maharashtra	8	378.0	16 November 1998	November 2000	MRTH	Completed
Nasirabad ROB	6	Maharashtra	30 m	104.5	16 November 1998	November 1999	MRTH	Completed
Wainganga Bridge	6	Maharashtra	530 m	326.0	16 November 1998	May 2001	MRTH	Completed
Mahi Bridge	8	Gujarat	–	420.0	16 November 1998	April 2000	MRTH	Completed
ROB Kishangarh Bypass	8	Rajasthan	1	166.6	27 November 1998	25 April 2000	NHAI	Completed
Bridge across river Watrak	8	Gujarat	–	482.0	1 March 1999	31 March 2001	MRTH	In progress
Moradabad Bypass	24	Uttar Pradesh	18	1000.0	23 April 1999	23 October 2001	NHAI	In progress
Derabassi ROB	22	Punjab	–	358.0	8 September 1999	–	MRTH	Completed

MRTH – Ministry of Road Transport and Highways; NHAI – National Highways Authority of India

[a] completed and open to traffic

Source
MoF. 2001. ***Economic Survey 2000/01***. New Delhi: Ministry of Finance.

Table 2.66 Utilization of fleet (for reporting state road transport undertakings): 1998/99

Description	*Rural*	*Hill region*	*Urban*	*Total*
Average no. of buses held	95 310.0	2 659.0	17 455.0	115 424.0
Average no. of buses off-road	8 016.0	315.0	1 669.0	10 000.0
Average no. of spare buses	1 126.0	–	534.0	1 660.0
Average no. of buses on road	86 168.0	2 344.0	15 252.0	103 764.0
Fleet utilization (%)	90.4	88.2	87.4	89.9
Effective km (million)	1 033 865.3	18 315.8	123 966.6	1 176 147.7
Dead km (million)	16 551.6	257.2	3 871.1	20 679.9
Gross km (million)	1 050 416.9	18 573.0	127 837.7	1 196 827.6
Bus utilization per km (km)				
on buses on road	328.7	214.1	222.7	310.5
on buses held	297.2	188.7	194.6	279.2

Source

ASRTU. 2000. ***State Transport Undertakings: Profile and Performance 1998/99.*** p. 108.
New Delhi: Association of State Road Transport Undertakings.

Table 2.67 Road accidents (thousands): 1991 to 1998

Item	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*[a]	*1997*[a]	*1998*[a]
Number of accidents	293.5	260.3	280.1	320.4	348.9	272.0	290.9	300.0
Persons killed	56.6	59.7	60.9	64.0	70.6	69.8	74.2	76.7
Persons injured	255.0	267.2	287.8	311.5	323.2	330.0	309.5	320.5
Vehicle population	21 374	23 507	25 505	27 660	30 295	33 783	37 231	40 939

[a] provisional

Source

1 MoST. ***Handbook of Management Information*** (various issues). New Delhi: Transport Research Wing, Ministry of Surface Transport.
2 MoST. 2001. ***Motor Transport Statistics of India, 1997/98***. New Delhi: Transport Research Wing, Ministry of Surface Transport.

Table 2.68 Motor vehicle accidents (**numbers**) in metropolitan cities: 1996 to 1998

	1996			*1997*			*1998*		
City	*Number of accidents*	*Persons killed*	*Persons injured*	*Number of accidents*	*Persons killed*	*Persons injured*	*Number of accidents*	*Persons killed*	*Persons injured*
Ahmedabad	2 573	215	2 401	3 229	239	3 038	2 949	218	2 949
Bangalore	8 474	715	6 566	8 722	704	6 637	8 360	726	6 358
Chennai	5 458	615	3 783	5 171	749	3 797	5 121	682	4 813
Coimbatore	1 150	179	1 090	1 152	198	888	1 301	–	–
Delhi	11 315	2 361	10 558	10 957	2 342	10 700	10 217	2 123	8 948
Hyderabad	2 034	342	2 080	2 108	377	2 000	2 208	370	1 981
Indore	2 354	174	1 687	2 370	171	–	2 140	151	–
Jaipur	1 922	263	1 461	2 022	303	1 557	2 077	302	1 735
Kochi	2 379	144	2 492	2 363	142	2 342	2 418	147	2 300
Kolkata	9 294	474	3 133	10 260	471	3 046	10 999	454	3 446
Ludhiana	256	162	142	–	–	–	–	–	–
Madurai	778	110	563	941	203	631	1 440	334	1 506
Mumbai	29 808	405	7 577	27 421	401	6 475	26 980	370	6 614
Nagpur	1 575	217	1 207	1 496	387	1 784	1 644	204	1 414
Pune	2 279	283	1 980	2 687	320	2 504	2 644	369	2 277
Surat	1 379	133	1 048	1 434	152	1 175	1 440	152	1 090
Vadodara	1 669	141	1 178	1 780	142	1 320	1 897	144	1 447
Visakhapatnam	773	158	760	890	218	938	990	216	998

Source

MoST. ***Handbook of Management Information*** (various issues). New Delhi: Transport Research Wing, Ministry of Surface Transport.

Table 2.69 Railway traffic: 1970/71 to 1999/2000

Traffic	*1970/71*	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Passengers (million)														
Suburban (million)	1 219	1 639	2 000	1 884	2 259	2 412	2 282	2 302	2 430	2 484	2 578	2 657	2 668	2 771
Non-suburban (million)	1 212	1 306	1 613	1 549	1 599	1 637	1 467	1 406	1 485	1 534	1 575	1 691	1 743	1 814
Total (million)	2 431	2 945	3 613	3 433	3 858	4 049	3 749	3 708	3 915	4 018	4 153	4 348	4 411	4 585
Revenue-earning goods traffic (million tonnes)	167.9	196.8	195.9	258.5	318.4	338.0	350.1	358.7	365.0	390.7	409.0	429.0	421.0	456.0
Gross earnings (million rupees)														
Passenger traffic	2 960	5 140	8 270	17 200	31 470	36 850	43 150	48 952	54 588	61 130	66 161	75 540	85 267	95 556
Goods traffic	6 180	11 510	16 180	43 760	84 080	94 620	106 638	122 755	134 236	149 728	163 542	195 950	196 758	217 550

Sources

1 MoR. ***Indian Railways, Annual Report and Accounts*** (various issues). New Delhi: Railway Board, Ministry of Railways.

2 MoR. ***Indian Railways Yearbook*** (various issues). New Delhi: Railway Board, Ministry of Railways.

Table 2.70 Electrification of railway routes and tracks (km): 1970/71 to 1999/2000

Routes/tracks	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Routes													
Electrified	3 706	5345	6517	9968	10653	11064	11260	11772	12306	13018	13490	13765	14261
Total	59 790	61240	61836	62367	62458	62486	62462	62660	62915	62725	62495	62809	62759
Running tracks													
Electrified	7447	10474	12367	18954	20049	20819	21223	21866	22684	24101	25238	25773	26809
Total	71669	75860	77153	78607	78969	79200	79188	79495	80441	80754	80908	81511	81252
Number of stations	7066	7035	7092	7100	7116	7043	7050	7056	7068	6984	6929	6896	6867

Source

MoR. ***Indian Railways, Annual Report and Accounts*** (various issues). New Delhi: Railway Board, Ministry of Railways.

Table 2.71 Energy intensity in railways (**consumption per thousand gross tonne-km**): 1996/97 to 1999/2000

	1996/97			*1997/98*			*1998/99*			*1999/2000*		
Fuels	*Broad gauge*	*Metre gauge*	*Total including narrow gauge*	*Broad gauge*	*Metre gauge*	*Total including narrow gauge*	*Broad gauge*	*Metre gauge*	*Total including narrow gauge*	*Broad gauge*	*Metre gauge*	*Total including narrow gauge*
Passenger and proportion of mixed												
Coal (kg)	–	81.7	85.0	–	75.2	82.2	–	92.5	103.6	–	153.4	201.5
Diesel oil (litres)	5.1	5.6	5.2	5.3	5.1	5.3	5.2	6.0	5.3	4.8	5.8	4.9
Electricity (kWh)	20.6	15.4	20.6	20.6	13.7	20.6	20.6	19.7	20.6	20.6	22.9	20.6
Goods and proportion of mixed												
Coal (kg)	–	238.0	240.0	–	382.4	381.6	–	793.6	793.6	–	977.1	977.1
Diesel oil (litres)	3.1	4.6	3.2	3.1	4.8	3.2	3.0	4.8	3.0	3.0	5.4	3.0
Electricity (kWh)	8.9	4.5	8.9	8.7	4.9	8.7	8.1	8.0	8.1	8.0	7.5	8.3

Source

MoR. ***Indian Railways, Annual Report and Accounts*** (various issues). New Delhi: Ministry of Railways.

Table 2.72 Trends in relative rail and road traffic: 1970/71 to 1996/97

Mode	*1970/71*	*1973/74*	*1976/77*	*1979/80*	*1982/83*	*1985/86*	*1988/89*	*1996/97*
Freight traffic								
Rail (%)	65.50	61.50	62.30	54.60	48.60	48.70	48.00	40.00
Road (%)	34.50	38.50	37.70	45.40	51.40	51.30	54.00	60.00
Total (billion tonne-km)	194.41	199.05	251.53	285.85	365.89	422.68	505.00	–
Passenger traffic								
Rail (%)	32.90	31.60	29.70	27.90	23.70	22.20	23.00	20.00
Road (%)	67.10	68.40	70.30	72.10	76.30	77.80	77.00	80.00
Total (billion passenger-km)	359.05	427.60	549.33	710.40	955.90	1079.20	1169.00	–

Sources

1 CMIE. ***Basic Statistics Relating to the Indian Economy*** (various issues). Mumbai: Centre for Monitoring Indian Economy.
2 MoR. 1998. ***Status Paper on Indian Railways.*** New Delhi: Ministry of Railways. (For 1996/97)
3 MoF. 1999. ***Economic Survey.*** New Delhi: Ministry of Finance.

For more details, please see TEDDY ONLINE+ [Section: Transport (general)]

Table 2.73 Indian shipping gross registered tonnage (million): 1971 to 1999

Items	*1971*	*1981*	*1985*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*[a]	*2000*[a]
Number of ships															
Coastal	62	65	95	151	162	169	187	202	206	219	231	232	247	269	276
Overseas	193	338	273	254	256	246	254	241	231	251	253	244	237	241	238
Total	255	403	368	405	418	415	441	443	437	470	484	476	484	510	514
Shipping Corporation of India	77	147	146	126	127	127	128	125	121	123	121	117	118	113	111
Gross registered tonnages (million)															
Coastal	0.22	0.30	0.30	0.48	0.52	0.56	0.64	0.64	0.68	0.68	0.70	0.60	0.60	0.70	0.66
Overseas	2.28	5.59	5.65	5 45	5 50	5.38	5.65	5.63	5.67	6.30	6.30	6.20	6.10	6.40	6.20
Total	2.50	5.89	5.95	5.93	6.02	5.94	6.29	6.27	6.35	7.00	7.00	6.80	6.70	7.10	6.86
Shipping Corporation of India	0.87	3.02	3.24	2.90	2.96	3.01	3.00	2.95	3.03	3 18	3.10	3.00	3.10	3 00	3.00

[a] up to September

Note
Figures pertain to the end of the year or quarter

Sources

1 MoST. 1998. ***Handbook of Management and Information.*** p. 29. New Delhi: Transport Research Wing, Ministry of Surface Transport. 52 pp.
2 MoST. 1998. ***Indian Shipping Statistics.*** p. 8. New Delhi: Transport Research Wing, Ministry of Surface Transport.

Table 2.74 Cargo carried and freight earned by the Central Inland Water Transport Corporation by commodity: 1996/97 to 1999/2000

Commodity	*1997/98* Tonnes carried	Freight earned (million rupees)	*1998/99* Tonnes carried	Freight earned (million rupees)	*1999/2000* Tonnes carried	Freight earned (million rupees)
Rice	–	–	1 755	100	4 502	187
Fertilizers	13 549	691	576	14	–	–
Cement	6 874	338	424	21	1 163	66
Coal	1 000	38	997	114	–	–
Jute	–	–	–	–	1 200	67
General cargo	4 201	225	5 846	327	2 941	206
Fresh water	1 601	203	297	11	150	5
Pulses	50 966	1 997	4 000	138	6 696	278
Paper	–	–	–	–	2 992	233
Petroleum, oil, and lubricants	118 400	1 314	24 572	353	–	–
Towing/hire/dentation charges additional freight	–	1 935	–	3 245	–	–
Wheat flour	–	–	18 000	603	–	–
Sugar	14 475	225	37 887	1 052	138 055	4 908
Boulder	–	–	–	–	–	–
Other dry cargo	–	34	594	62	–	–
Rock phosphate cake	5 902	92	–	–	–	–
D Peas	–	–	–	–	–	–
Limestone	–	–	100	4	–	–
Billet	–	–	–	–	–	–
Met coke	3 570	144	–	–	–	–
Bitumen	3 000	339	–	–	–	–
Rail	5 113	134	–	–	–	–
Bamboo	2 855	131	–	–	–	–
Log steel	11 600	181	5 000	125	3 581	70
Project cargo	–	–	4 131	573	–	–
Silica sand	–	–	228	5	–	–
Accessories	–	–	1 037	160	–	–
Plate iron	–	–	3 000	44	–	–
Towage	–	–		5	–	–
Steel spares	–	–	1 500	60	–	–
Sponge Iron	–	–	2 700	157	1 531	97
Allahabad projects	–	–		100	–	164
Miscellaneous	–	–	28 501	875	–	–
Total	243 106	8 024	141 145	8 147	251 256	12 024

Source

MoST. 2001. ***Statistics of Inland Water Transport 1999/2000***. New Delhi: Transport Research Wing, Ministry of Surface Transport.

Table 2.75 Capacity available at major ports (**million tonnes**): 1992 to 2000

Commodity	*Eighth Plan target*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Petroleum, oil, and lubricants	106.15	78.00	78.00	78.00	78.00	80.00	94.92	96.92	105.70	118.50
Iron ore	42.50	41.50	41.50	41.50	41.50	41.50	44.50	44.50	43.00	43.00
Coal	42.00	7.00	7.00	8.00	8.00	8.00	9.00	9.00	15.60	16.80
Fertilizer	6.60	7.95	7.95	7.95	7.95	7.95	5.65	5.65	4.85	3.45
Container	17.33	6.83	8.38	8.62	8.98	8.98	13.91	13.91	22.90	24.70
General cargo	38.91	27.45	28.20	29.07	29.58	31.03	47.23	47.68	47.45	51.60
Total	253.49	169.23	171.03	173.14	174.01	177.46	215.21	217.66	239.50	258.05

Note
as on 31 March

Sources

1 GoI. 1997. ***Annual Plan 1996/97***. p. 367. New Delhi: Planning Commission, Government of India.

2 MoST. 1998. ***Handbook of Management and Information***, p. 5. New Delhi: Transport Research Wing, Ministry of Surface Transport. 52 pp.

3 MoST. 2000. ***Basic Port Statistics of India, 1999/2000***. New Delhi: Transport Research Wing, Ministry of Surface Transport.

Table 2.76A Cargo traffic handled (**million tonnes**) (commoditywise) at major ports: 1970/71 to 1998/99

Commodity	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*
Petroleum, oil, and lubricants	18.89	33.58	54.89	64.00	67.60	73.76	76.92	80.37	90.92	99.05	105.34	108.23
Fertilizer raw material	2.27	6.20	6.81	8.94	9.92	9.91	9.47	11.00	12.36	9.91	12.56	12.56
Iron ore	19.20	22.84	28.84	31.73	31.60	29.83	34.10	34.35	34.56	33.26	39.61	32.82
Coal	0.68	2.11	7.54	19.66	22.40	24.49	26.81	30.80	33.79	37.53	42.30	42.87
Foodgrains	3.19	0.98	1.13	1.53	1.54	2.80	1.96	1.34	3.85	4.18	4.00	4.71
Others	11.34	14.56	20.41	25.63	23.08	25.71	29.76	38.02	39.73	43.03	47.98	50.54
Total	55.57	80.27	119.61	151.67	156.64	166.50	179.02	195.89	215.21	226.97	251.66	251.74
of which:												
unloaded	25.56	46.82	67.97	85.09	86.57	97.92	100.25	113.20	126.65	139.21	155.98	164.53
loaded	30.02	33.45	51.64	66.58	70.08	68.58	78.77	82.69	88.56	87.76	95.68	87.21

Note

Since 1989/90, fertilizer raw material includes liquid raw fertilizer also.

Sources

1 MoST. 1995. ***Basic Port Statistics of India, 1994/95***. p. 33. New Delhi: Transport Research Wing, Ministry of Surface Transport. 196 pp.

2 MoST. 1996. ***Basic Port Statistics of India, 1995/96***. p. 56. New Delhi: Transport Research Wing, Ministry of Surface Transport. 263 pp.

3 MoST. 1997. ***Basic Port Statistics of India, 1996/97***. p. 6. New Delhi: Transport Research Wing, Ministry of Surface Transport. 263 pp.

4 MoST. 1998. ***Handbook of Management and Information***. p. 1. New Delhi: Transport Research Wing, Ministry of Surface Transport. 52 pp.

5 MoST. 2000. ***Basic Port Statistics of India, 1999/2000***. p. 74. New Delhi: Transport Research Wing, Ministry of Surface Transport. 263 pp.

Table 2.76B Cargo traffic handled (**million tonnes**) (commoditywise) at minor ports: 1990/91 to 1998/99

Item	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*
Fertilizer and raw material	2.63	2.15	3.01	2.28	1.65	2.61	1.94	3.93	2.73
Iron and other ore	0.95	0.36	0.49	0.44	5.18	4.69	5.74	6.64	7.64
Oil cakes	1.71	2.07	2.37	2.48	2.15	2.04	2.20	2.14	1.32
Building material	1.86	1.80	1.53	1.55	4.04	4.10	4.14	3.40	6.52
Salt	0.17	0.17	0.17	0.25	0.18	0.17	0.26	0.11	0.17
Others	5.46	6.71	7.84	12.47	9.08	12.10	13.55	22.39	17.88
Total	12.78	13.26	15.41	19.47	22.28	25.71	27.83	38.61	36.31
Passenger traffic handled (million)	14.16	15.59	14.95	15.41	15.63	17.79	15.15	17.04	15.32

Source

MoST. 2000. ***Basic Port Statistics of India, 1999/2000.*** New Delhi: Ministry of Surface Transport.

Table 2.77 Commodity traffic at various ports (**million tonnes**): 1996/97 and 1997/98

Ports	*Mineral oil and POL*		*Iron ore*		*Coal*		*Fertilizers*		*Food grains*		*Other dry cargo*		*Total*	
	1997/98	*1998/99*	*1997/98*	*1998/99*	*1997/98*	*1998/99*	*1997/98*	*1998/99*	*1997/98*	*1998/99*	*1997/98*	*1998/99*	*1997/98*	*1998/99*
Chennai	11.6	10.6	6.2	5.4	10.5	11.9	0.9	1.2	0.2	0.1	5.7	6.0	5.5	35.2
Jawaharlal Nehru Port Trust	0.7	1.3	0.7	0.5	–	–	0.9	0.9	0.4	0.4	6.2	8.6	8.9	11.7
Kandla	29.0	30.5	–	–	–	–	0.7	2.2	1.4	1.7	6.2	6.3	38.9	40.7
Kochi	9.6	9.7	–	–	0.1	0.2	0.2	0.7	0.2	0.3	1.6	1.8	12.3	12.7
Kolkata/Haldia	14.3	15.7	–	–	7.7	7.5	0.1	0.7	–	0.1	5.3	5.3	28.2	29.3
Mormugao	1.1	1	18.7	15.1	0.5	0.7	–	0.2	–	–	0.6	1.0	21.2	18.0
Mumbai	17.7	17.3	–	–	–	–	0.1	0.1	1.1	1.1	12.4	11.6	32.1	30.1
New Mangalore	7.0	7.2	6.5	5.3	0.1	0.1	0.2	0.2	0.3	0.4	0.9	0.9	15.3	14.1
Tuticorin	0.5	0.4	–	–	5.6	5.2	0.5	1.3	0.1	0.2	2.6	3.0	10.0	10.1
Paradip	1.7	2	1.4	0.8	7.9	8.2	0.1	1.1	–	–	1.1	1.0	13.3	13.1
Visakhapatnam	12.1	12.5	6.1	5.6	9.9	9.2	1.0	2.8	0.3	0.3	5.4	5.2	36.0	35.6

POL - petroleum, oil, and lubricants

Sources

1 Planning Commission. 1994. ***Compendium of Transport Statistics***, pp. 85-88. New Delhi: Transport Division, Planning Commission, Government of India. 141 pp.

2 MoST. ***Basic Port Statistics of India*** (various issues). New Delhi: Transport Research Wing, Ministry of Surface Transport.

Table 2.78 Private sector/captive port projects approved: as on 31 December 1999

Scheme	*Port*	*Capacity*	*Project cost*	*Name of party and status*
Container terminal	JNPT (Jawaharlal Nehru Port)	7.8	8 000	The project of 2 berths awarded to NSICT, a consortium led by P&O Ports, Australia in 1997. One berth opened during 1999. Second berth opened in August 1999.
Liquid cargo berth	JNPT	5.5	2 000	Bharat Petroleum Corporation Ltd and Indian Oil Corporation Ltd, agreement between joint ventures and JNPT signed in August 1999.
Fifth oil jetty	Kandla	2.0	210	Indian Farmers Fertilizers Cooperation Ltd. Completed.
Oil jetty at Vadnar	Kandla	15.0	14 000	Essar Oil Ltd. The project is under construction.
Oil jetty	Kandla	2.0	900	Indian Oil Corporation Ltd. Construction of Jetty in progress.
Container terminal	Tuticorin	3.6	1 000	Port of Singapore Authority Terminal operational with effect from 21 December 1999.
Oil jetty	Kandla	2.0	900	Hindustan Petroleum Corporation Ltd. Construction will commence after December 1999. Position being ascertained.
Multipurpose berth 5A and 6A	Mormugao	5.0	2 500	ABG Ltd. Agreement signed on 11 April 1999.
Captive coal berth to SPIC Electric Corporation	Tuticorin	1.5	2 500	Government approved conveyed in April 1999
Captive berth to Oswal Fertilizers Ltd	Paradip	2.5	1 000	Approved in July 1999 work in progress
Development and operation of container terminal	Kandla	2 4	3 000	P&O Ports Australia have been awarded the project. However, agreement is yet to be signed.
Captive coal and general cargo berth at Pirpan Mumbai	Mumbai	1.5	2 500	The issue regarding award of contract to Tata Electric Company is under consideration in the light of points raised by the Ministry of Law.

Source
MoST. 2000. ***Annual Report 1999/2000***. New Delhi: Ministry of Surface Transport.

Table 2.79 Growth of civil aviation: 1970/71 to 1999/2000

Indicators	*1970/71*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*[a]
Fleet strength (number)													
Indian Airlines	73	49	54	59	55	57	58	62	59	54	54	53	53
Vayudoot	–	–[b]	3	17	17	16	–	–	–	–	–	–	–
Revenue tonne-km (million)													
Air India	275.0	980.1	1110.0	1381.0	1140.5	1090.5	1093.8	1385.0	1619.0	1499.5	1502.4	1473.6	1456.5
Indian Airlines	200.0	400.0	720.0	699.2	761.0	685.3	695.0	686.3	723.0	765.0	827.5	841.0	871.2
Vayudoot[c]	–	–	7.0	19.9	18.7	11.0	–	–	–	–	–	–	–
Number of passengers carried (million)													
Air India	0.5	1.4	1.8	2.2	2.0	2.2	2.0	2.5	2.8	2.9	3.1	3.2	3.4
Indian Airlines	2.1	5.4	9.1	7.9	8.9	7.8	7.9	7.8	7.7	8.2	8.4	8.0	8.0
Vayudoot[c]	–	0	0.2	0.6	0.5	0.2	–	–	–	–	–	–	–
Passengers handled at the IAAI (International Airports Authority of India) airports (million)	–	10.7	17.1	17.7	18.8	18.8	21.0	22.9	25.6	36.5	36.5	37.0	39.0
Cargo handled at the IAAI airports (thousand tonnes)	–	178.7	331.0	377.3	270.3	391.4	435.4	494.0	561.6	681.2	706.0	699.0	797.0

[a] provisional

[b] aircraft leased from the Indian Airlines

[c] Vayudoot stands merged with the Indian Airlines

Source

MoF. 2001. ***Economic Survey 2000/01***. p. S-32. New Delhi: Ministry of Finance.

Table 2.80 Annual comparative statement of scheduled services of national carriers

	Total traffic					*Traffic on domestic scheduled service*				
	Year			*Variation (%)*		*Year*			*Variation (%)*	
Operations	*1994/95*	*1993/94*	*1992/93*	*1994/95 over 1993/94*	*1993/94 over 1992/93*	*1994/95*	*1993/94*	*1992/93*	*1994/95 over 1993/94*	*1993/94 over 1992/93*
Passenger carried (thousands)	9 863	9 832	10 212	0.3	-3.7	7 272	7 510	7 888	-3.2	-4.8
Passenger-km performed (million)	16 479	15 235	15 603	8.2	-2.4	6 545	6 779	7 063	-3.5	-4.0
Available seat-km (million)	25 887	24 010	22 880	7.8	4.9	10 297	10 821	10 397	-4.8	4.1
Passenger load factor (%)	63.7	63.5	68.2	0.3	-7.0	63.6	62.6	67.9	1.5	-7.8
Freight carried (thousand tonnes)	169.2	143.5	139.1	17.9	3.2	78.6	72.4	0.3	8.6	-5.1
Mail carried (thousand tonnes)	19.5	19.6	18.0	-0.5	8.9	18.2	18.1	16.4	0.6	10.4
Tonne-km performed (million)										
Passenger	1 455.6	1 335.7	1 369.8	9.0	-2.5	543.8	558.6	587.7	-2.6	-5.0
Freight	584.2	421.9	380.6	38.5	10.9	81.1	75.1	81.3	8.0	-7.6
Mail	28.5	29.7	26.5	-4.0	12.1	20.1	20.1	18.5	–	8.6
Total	2 068.3	1 787.3	1 776.9	15.7	0.6	645.0	653.8	687.5	-1.3	-4.9
Total available tonne-km (million)	3 339.2	2 964.3	2 853.5	12.6	3.9	1 122.1	1 144.7	1 101.8	-2.0	3.9
Weight load factor (%)	61.9	60.3	62.3	2.7	-3.2	57.5	57.1	62.4	0.6	-8.5

Source

DGCA. 1995. ***India Air Transport Statistics, 1994/95***. New Delhi: Directorate of Regulations and Information, Director General of Civil Aviation.

Table 2.81 Physical performance of the Indian Airlines: 1993/94 to 1999/2000

Particulars	*Unit*	*1993/94*	*1994/95*	*1995/96*	*1996/97*	*1997/98*	*1998/99*	*1999/2000*
Available tonne kilometres	Million	1056.89	1025.75	1045.81	1075.24	1094.13	1122.92	1120.93
Revenue tonne kilometres	Million	695.29	686.33	722.69	698.12	700.90	709.08	740.29
Overall load factor	%	65.8	66.9	69.1	64.9	64.1	63.1	66.0
Revenue pax carried	Million	7.89	7.64	7.74	7.10	6.36	6.07	5.93
Freight including excess baggage	Tonnes	85204	87854	93430	85766	82150	86317	91392

Source

MoCA. 2001. ***Annual Report 2000/01***. New Delhi: Ministry of Civil Aviation.

Table 2.82 Total domestic passenger traffic (**million**) carried by the Indian Airlines, the Air India, and the Vayudoot: 1985/86 to 1994/95

Year	*Indian Airlines*	*Air India*	*Vayudoot*	*Total*
1985/86	8.60	0.20	0.20	9.00
1986/87	9.40	0.20	0.30	9.90
1987/88	9.90	0.30	0.40	10.60
1988/89	9.54	0.30	0.45	10.29
1989/90	9.39	0.38	0.14	9.91
1990/91	7.47	0.39	0.44	8.30
1991/92	8.31	0.30	0.30	8.91
1992/93	7.27	0.31	0.21	7.79
1993/94	7.23	0.28	–	7.51[a]
1994/95	6.90	0.37	–	7.27[a]

[a] exclusive of Vayudoot figures

Source

DGCA. 1995. ***India Air Transport Statistics 1994/95***. New Delhi: Directorate of Regulations and Information, Director General of Civil Aviation.

Table 2.83 Total domestic and operating statistics of the Indian Airlines, the Air India, and the Vayudoot

	Aircraft flown		*Passengers*												
							Cargo carried (tonne)			*Tonne-km performed (thousand)*					
Year	*Hours*	*km* (thousand)	*Carried*	*Km performed* (thousand)	*Available seat-km* (thousand)	*Pax load load factor* (%)	*Freight*	*Mail*	*Total*	*Pax*	*Freight*	*Mail*	*Total*	*Available tonne-km*	*Weight load factor* (%)
1991/92	135 839	67 763	8 919 200	7 930 803	11 653 126	68.1	86 137	15 687	101 824	654 243	92 484	17 240	763 967	1 244 571	61.4
1992/93	122 574	60 974	7 887 877	7 146 702	10 397 137	68.7	76 346	16 436	92 762	587 690	81 261	18 531	687 482	1 101 836	62.4
1993/94[a]	105 256	58 190	7 510 498	6 778 617	10 820 752	62.6	72 406	18 185	90 591	558 696	76 183	20 142	654 021	1 144 713	57.1
1994/95[a]	101 855	57 777	7 271 833	6 544 989	10 297 469	63.6	78 654	18 183	96 837	543 842	81 111	20 084	645 037	1 122 093	57.5

[a] data exclude Vayudoot figures

Source

DGCA. 1995. *India Air Transport Statistics 1994/95* New Delhi: Directorate of Regulations and Information, Director General of Civil Aviation.

Table 2.84 Total traffic and operating statistics of all scheduled services of the Indian Airlines: 1985 to 1997/98

Year	*Aircraft flown*		*Passengers*											*Available*	*Weight*
				km	*Available*	*Pax*	*Cargo carried (tonne)*			*Tonne-km performed (thousand)*				tonne-	*load*
	Hours	*km* (thousand)	*Carried*	*performed* (thousand)	*seat-km* (thousand)	*load factor* (%)	*Freight*	*Mail*	*Total*	*Pax*	*Freight*	*Mail*	*Total*	km	*factor* (%)
1985	124 929	62 351	9 081 600	7 141 886	9 619 779	74.2	104 497	18 385	122 882	582 215	104 966	18 413	705 594	1 012 183	69.7
1986	132 898	67 312	9 695 349	7 817 061	10 550 259	74.1	97 500	17 853	115 353	643 695	98 513	17 742	759 950	1 088 896	69.8
1987/88	135 435	70 425	10 454 850	8 645 226	11 049 886	78.2	109 585	16 491	126 076	709 813	112 149	18 035	839 997	1 145 141	73.4
1988/89	123 248	67 516	10 082 619	8 659 433	10 742 812	80.6	111 442	16 877	128 319	706 144	113 793	18 494	838 431	1 095 882	76.5
1989/90	116 832	65 382	9 830 138	8 611 625	11 230 686	76.7	101 308	16 433	117 741	702 864	103 869	17 184	82 397	1 130 472	72.9
1990/91	94 690	51 985	7 854 444	7 188 215	9 106 368	78.9	85 851	15 175	101 026	589 412	91 937	16 285	697 634	923 302	75.6
1991/92	114 750	61 720	8 871 801	7 979 314	10 866 776	73.4	82 486	15 889	98 375	654 202	88 469	16 982	759 653	1 086 886	69.9
1992/93	103 073	54 956	7 806 764	7 187 868	9 768 235	73.6	72 374	16 605	88 979	588 699	77 621	17 913	684 233	965 707	70.9
1993/94	107 340	59 521	7 884 376	7 237 448	10 595 678	68.3	72 186	18 326	90 512	597 953	76 466	20 139	694 558	1 055 762	65.8
1994/95	105 544	59 643	7 611 191	6 981 609	10 019 710	69.7	76 705	18 297	95 002	582 791	80 904	20 146	683 841	1 022 264	66.9
1995/96	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1996/97	–	–	–	–	–	–	–	–	–	–	–	–	–	1 075 238	64.9
1997/98	–	–	–	–	–	–	–	–	–	–	–	–	–	1 094 132	64.1

Sources

1 DGCA. 1995. ***India Air Transport Statistics 1994/95***. New Delhi: Directorate of Regulations and Information, Director General of Civil Aviation.

2 MoCA. 1999. ***Annual Report 1998/99***. New Delhi. Ministry of Civil Aviation.

Table 2.85 Total traffic and operating statistics of all scheduled services of the Air India: 1985 to 1997/98

	Aircraft flown		*Passengers*												
							Cargo carried (tonne)			*Tonne-km performed (thousand)*					
Year	*Hours*	*km (thousand)*	*Carried*	*km performed (thousand)*	*Available seat-km (thousand)*	*Pax load factor (%)*	*Freight*	*Mail*	*Total*	*Pax*	*Freight*	*Mail*	*Total*	*Available tonne-km*	*Weight load factor (%)*
1985	61 795	42 556	1 742 295	7 620 417	11 071 839	68. 8	73 453	3 074	76 527	696 288	408 998	14 734	1 120 020	1 805 949	62.0
1986	61 764	42 077	1 789 870	7 608 528	11 062 882	68 8	79 050	1 967	81 017	709 179	439 902	9 855	1 158 936	1 866 169	62.1
1987/88	73 932	50 523	2 119 089	9 007 649	12 986 744	69 4	97 618	1 847	99 465	835 779	505 771	9 379	1 350 929	2 169 152	62.3
1988/89	72 543	50 019	2 110 200	8 948 507	13 473 795	66. 4	96 700	1 357	98 057	828 602	531 841	7 924	1 368 367	2 163 562	63.2
1989/90	74 003	52 053	2 238 335	9 268 568	14 460 469	64. 1	106 495	1 456	107 951	855 997	574 049	8 952	1 438 998	2 259 504	63.7
1990/91	67 548	47 838	2 046 847	8 492 761	12 736 721	66. 7	95 212	1 661	96 873	783 593	548 627	10 454	1 342 674	2 152 423	62.4
1991/92	68 941	46 963	1 983 492	8 078 244	13 129 624	61. 5	75 621	1 915	77 536	747 144	380 612	12 787	1 140 543	1 946 737	58.8
1992/93	66 990	46 518	2 178 706	8 415 969	12 991 472	64. 8	66 845	1 196	68 041	774 507	302 944	8 622	1 086 073	1 876 969	57.9
1993/94	68 880	47 909	1 947 374	7 997 614	13 414 297	59. 6	71 373	1 420	72 793	737 822	345 574	9 652	1 093 048	1 908 608	57.3
1994/95	78 943	55 554	2 251 437	9 497 450	15 867 729	59. 9	92 509	1 169	93 678	872 883	503 281	8 392	1 384 556	2 316 915	59.8
1995/96	–	–	–	–	–	–	–	–	–	–	–	–	–	1 045 800	–
1996/97	271 200	–	2 910 000	11 588 600	17 652 000	65. 7	–	–	–	–	–	–	–	2 452 100	60.5
1997/98	270 500	–	2 930 000	11 422 400	16 933 300	67. 5	–	–	–	–	–	–	–	2 293 700	63.4

Sources

1 DGCA. 1995. ***India Air Transport Statistics 1994/95***. New Delhi: Directorate of Regulations and Information, Director General of Civil Aviation.

2 MoCA. 1999. ***Annual Report 1998/99***. New Delhi: Ministry of Civil Aviation.

Table 2.86 Aviation Turbine Fuel offtake (**thousand tonnes**): 1970/71 to 1999/2000

ATF	*Offtake*
1970/71	689
1980/81	1125
1985/86	1453
1990/91	1677
1991/92	1559
1992/93	1565
1993/94	1741
1994/95	1903
1995/96	2082
1996/97	2158
1997/98	2108
1998/99	2112
1999/2000	2197

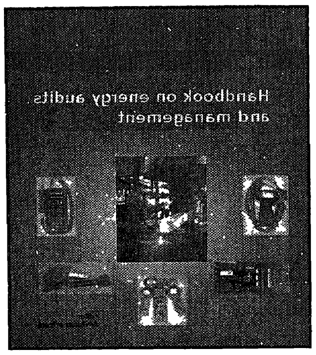
Sources

1 MoPNG. 2000. **Indian Petroleum Natural Gas Statistics** (various issues). New Delhi: Economic and Statistics Division, Ministry of Petroleum and Natural Gas.

2 MoPNG. 2000. **Basic Statistics of Petroleum and Natural Gas** (various issues). New Delhi: Ministry of Petroleum and Natural Gas.

Handbook on energy audits and management

Editor
Amit Kumar Tyagi



Energy audits play an important role in identifying energy conservation opportunities in the industrial sector. For any industrial unit, the first step in adopting a plan for improvement of energy efficiency is to carry out an energy audit.

Handbook on energy audits and management provides methodology for carrying out energy audits, with actual case studies based on TERI's past experience in this area and would enable users to understand the operation of various equipment and systems, and identify opportunities for energy saving in industrial units. It includes a list of manufacturers and suppliers of energy-efficient equipment and instruments used for energy auditing and provide methodology for carrying out energy audits, with actual case studies based on **TERI's** past experience in this area. The handbook covers almost all the major energy-consuming equipment, besides a chapter on policies of the Government of India and the financial aspects of energy conservation projects in industry.

Contents include

- Industrial energy conservation: a broad overview
- Boilers
- Steam distribution system
- Compressed air network
- Refrigeration and air-conditioning
- Pumps
- Electrical load management
- Electric motors
- Lighting
- Diesel generating sets
- Energy management information system
- List of instruments
- List of equipment suppliers / laboratories / government agencies

Softbound • 164 pp • ISBN 81-85419-71-X • Price Rs 1100 (Indian); US $40 (overseas)

All orders and enquiries to

TERI
Information Dissemination Services
Darbari Seth Block, Habitat Place
Lodhi Road, New Delhi – 110 003

Fax +91 11 468 2144 or 468 2145
E-mail outreach@teri.res.in
Telephone +91 11 468 2100 or 468 2111
Web site www.teriin.org

Domestic sector

At a glance

- Forty per cent of India's household energy needs are met by traditional biofuels and 90% of rural households depend primarily on these fuels.
- In urban households, particularly in the higher income classes, there is a decline in consumption of biofuels which is accompanied by growth in consumption of LPG (liquefied petroleum gas), kerosene, and electricity by about 9%, 3%, and 11% a year, respectively.
- By comparison, the consumption of commercial fuels like LPG is still negligible in the rural areas with only 1.3% households using the fuel for cooking.
- Fuelwood consumption is high in states that have considerable forest cover; for instance, in Arunachal Pradesh 10.4 kg of fuelwood as used per household per day and in Manipur 10.34 kg.
- Consumption of dung cakes is high in states like Uttar Pradesh (4.95 kg per household per day) and Rajasthan (3.41 kg per household per day) that have little biomass cover.
- Dependence on traditional fuels has several ecological and social consequences: the danger of excessive pressure on forest resources, contribution to greenhouse gas emissions by burning of biomass in inefficient traditional cookstoves; reduction in soil nutrient level when agricultural residues and animal dung are used as energy sources instead of fertilizers and very importantly, the heath impacts of carrying large head-loads of wood over long distances and the burning of biomass in inefficient and poorly vented appliances.

Introduction

The Indian energy sector has witnessed some reforms and progress, and energy use in Indian households has undergone some changes. Despite this, around 40% of the energy needs of Indian households continue to be met by traditional energy forms. This is particularly true of rural households, 90% of which are still dependent on biomass fuels like fuelwood, cow dung, and agricultural residue. In urban centres, it is estimated that one in three households uses such fuels.

Energy consumption and expenditure patterns in Indian households

Energy consumption patterns in the Indian domestic sector vary widely not only among rural and urban areas, but also across various income classes in urban areas. The heterogeneity of the social fabric and the disparity in lifestyles induce a great diversity in the standards of living and ways of satisfying energy requirements. Differences in energy use lie both in terms of the per capita energy consumption as well as in the choice of fuel to meet the energy demands. The levels and forms of fuel consumed by the household sector depend on income levels, size of settlements, households and city, price of fuels, the availability and access to modern commercial fuels and the efficiency of the end-use equipment used.

It has been observed that with higher levels of development in the economy and rising per capita incomes, households tend to switch from biomass fuels towards fuels such as kerosene and LPG (liquified petroleum gas) that are relatively cleaner, efficient, and convenient. The rising per capita income typically associated with urbanization increases demands for both end-use energy and energy-intensive products and services. Also, growth in disposable incomes induces changes in lifestyles and leads to increased energy demand, particularly for fuels such as electricity and LPG. Availability of these fuels is also crucial. This is particularly true in the case of kerosene where parallel marketing has enhanced supplies.

Figure 1 shows the percentage of population below different levels of MPCE (monthly per capita expenditure) based on the 50th round of NSSO (National Sample Survey Organization) data. In rural areas, almost 59% of the population lies below the MPCE level of 265 rupees, compared to only 28% of the urban population. Only 20% of the rural population had an MPCE of 355 rupees or more, compared to 51% in case of urban population. The average MPCE in the urban sector was 458 rupees, which is about 63% higher than the average MPCE in the rural sector, which was around 281 rupees.

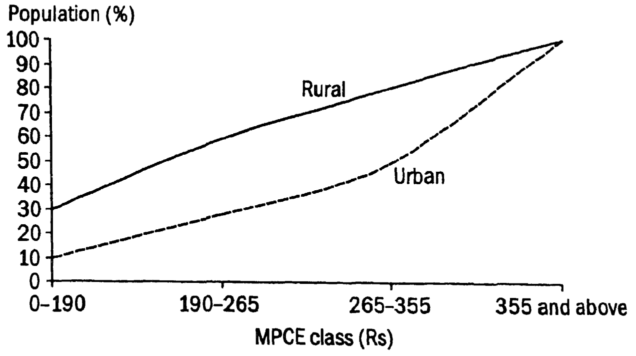
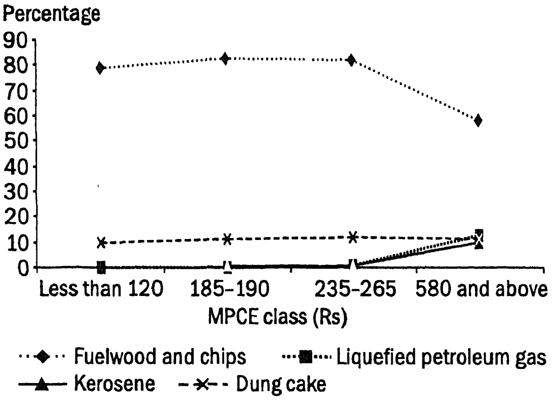


Figure 1 Population (%) under different MPCE (monthly per capita expenditure) classes



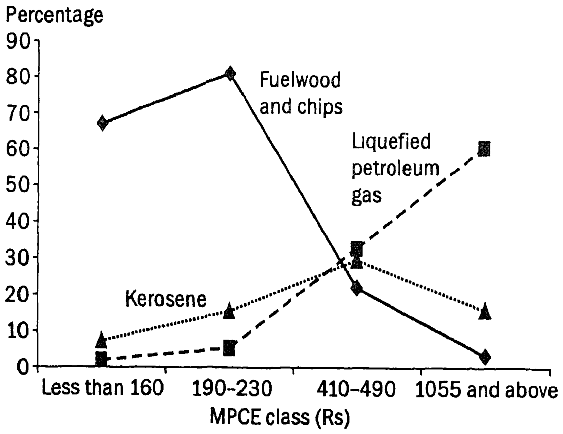
MPCE - monthly per capita expenditure

Figure 2 Rural households using primary fuel for cooking across income classes

Source NSSO (1997a)

Figure 2 indicates that among rural households, the use of fuelwood and chips declines and the use of kerosene and LPG increases with increase in incomes. However, the transition across income classes is not significant, with the result that even in the highest income category, over 70% of rural households depend on fuelwood, chips or dung cake for cooking.

On the other hand, household income emerges as the major determinant of the fuel choice among urban households. Figure 3 shows that the use of firewood for cooking decreased after



MPCE - monthly per capita expenditure

Figure 3 Urban households using primary fuel for cooking across income classes

Source NSSO (1997a)

attaining its peak value in the MPCE class ranging from 190 to 230 rupees. The same trend is also seen in the case of kerosene, although its peak value is attained in the higher MPCE class (410–490 rupees). In contrast to this, the use of gas experienced a marked upward trend with increase in MPCE classes.

The MPCE on fuel and light in rural areas was 21 rupees in the 50th round and 22 rupees in the 51st round. In urban areas, the corresponding figures were 30 rupees in the 50th round and 34 rupees in the 51st round of NSSO surveys. The total MPCE on non-food products for rural areas were 104 and 120 rupees, respectively, in the two rounds while in urban areas it was 208 and 237 rupees, respectively. As a percentage of total expenditure on non-food items, the rural MPCE on fuel and light has decreased from 20% to 18% while in urban areas it has remained at about 14% over the 50th and 51st rounds (NSSO 1995). Even though expenditure on fuel and light as a percentage of total expenditure on non-food items has decreased in the rural areas in the two rounds of survey, the figures indicate that the rural poor still spend a higher proportion of their expenditure to meet their energy needs.

Energy demands in the urban residential sector

A study on the pattern of per capita energy use in urban areas of Maharashtra and Uttar Pradesh revealed that cooking accounts for about 92% of the gross energy consumption by the poor, while it forms only 60%–70% of total energy use for the high-income groups (Bhatia 1988). It was also observed that the high-income group not only used more energy per capita, but also used high-quality, clean fuels such as LPG and electricity. In terms of gross energy use, high-income households in Pune used about 18% less energy per capita than those in low-income group. However, in terms of useful energy consumption, energy use per capita in the high-income group was higher by 112% when compared with the low-income group. This is largely due to the much higher efficiencies of end-use devices (cooking stoves) used by the high-income group. The high-income group consume significantly more electricity for lighting, water heating, and appliances. Electricity consumption for lighting and appliances (fans, refrigerators, televisions, radios, etc.) accounted for nearly 85% of total electricity usage.

Table I Monthly per capita consumption

	Rural		*Urban*	
All India	*1987/88*	*1993/94*	*1987/88*	*1993/94*
Fuelwood and chips (kg)	16.24	17.27	7.40	6.09
Electricity (kWh)	1.30	2.27	7.18	9.67
Kerosene (litre)	0.57	0.68	1.29	1.42
Liquefied petroleum gas (kg)	0.01	0.04	0.39	0.88

Source NSSO (1997a)

There is a decline in the per capita monthly consumption of firewood and chips in urban areas from 7.4 kg in 1987/88 to 6.1 kg in 1993/94 (Table I). The use of soft coke has also declined, but this may be due to its decreasing supplies. The use of kerosene and LPG has increased substantially, the latter particularly in the higher-income households. In urban areas, the LPG consumption increased at the rate of nine per cent a year between 1990/91 and 1994/95. During the same period, the consumption of kerosene rose by 3%, and electricity by 11%. The consumption of commercial energy sources has increased considerably over the past two decades. In particular, between 1970/71 and 1994/95, the annual consumption of electricity per household went up from 7 to 53 kWh; of motor spirit from 2.9 to 4.6 kg; of kerosene from 6.6 to 9.9 kg; and of cooking gas from 0.33 to 3.8 kg (Table II).

Table II Per capita annual consumption of selected fuels in households: 1970/71 to 1995/96

Year	*Electricity* (kWh)	*Motor spirit* (kg)	*Kerosene* (kg)	*Liquefied* petroleum gas (kg)
1970/71	7.0	2.9	6.6	0.33
1980/81	13.5	2.3	6.3	0.59
1990/91	38.2	4.2	10.0	2.88
1994/95	53.0	4.6	9.9	3.80
1995/96	–	5.1	10.2	4.18

Source TERI (1998a)

In urban areas, poor households are heavily dependent on biofuels with more than 30% of them using traditional energy fuels for cooking. However, unlike the rural areas, where most of the fuel required is gathered, the poor in urban areas have to buy biofuels. Further, unlike prices of commercial fuels used by the rich, prices of most fuels used by the poor are not administered by the government. The market price of fuelwood varies significantly across regions and is relatively high in the metropolitan areas and large cities. The high cost of fuelwood itself, coupled with the low efficiency of the device used for cooking, results in a relatively high cost of fuelwood per unit of useful energy consumption for the poor.

It is, therefore, probable that the poor not only use smoky and inconvenient fuels causing poor health, but also pay a relatively higher price for meeting comparable levels of useful energy use.

The prices of energy products have increased faster compared to other commodities. This is especially hard on the poor as energy forms the bulk of their household expenditure. Again, the price of kerosene is subsidized with a view to protect consumers, but the benefits of the subsidy are not directed to the poor in particular. As a result, the subsidy is often misdirected and, while the relatively cheap kerosene is often used for adulteration in the transport sector, poor consumers are unable to fulfil their total requirement of kerosene from the ration (fair-price) shops and depend in part on supplies from outside sources where they pay relatively higher prices. In a study of supplies in different regions of the country about 48% of the sample households said that kerosene supplies at the ration shops were inadequate (Planning Commission 1985). In 1993/94, the all-India urban price estimate for firewood was of the order of Rs 5.12/kg as against Rs 5.49/litre for kerosene and Rs 5.94/kg for LPG.

The NCAER (National Council of Applied Economic Research) has been conducting MISH (market information surveys of households) since 1985. This provides useful information on the purchase of selected manufactured consumer goods by the households. It is observed that there is an increasing trend in the purchase of electrical appliances such as televisions, refrigerators, washing machines, ceiling fans, electrical irons, and geysers. The increase of refrigerators and geysers is particularly significant: from 0.56 million in 1985/86 to 1.47 million in 1993/94 for refrigerators and from 76 000 to 249 000 in the case of geysers between 1989/90 and 1993/94. However, there remains a tremendous potential for the increase in penetration levels of energy consuming goods in the household sector. The NCAER study also indicates that though rural households have relatively low levels of penetration of electric appliances at present, this section too may be expected to move towards the use of commercial fuels and increase the use of electric household appliances.

Energy demands in the rural domestic sector

Biomass fuels provide 85%–90% of the domestic energy and 75% of all rural energy (Natarajan 1985). Fuelwood is the largest contributor to energy use in rural areas, followed by animal dung and crop residues (Figure 4).

In spite of significant increases in the supply of commercial energy, the consumption of commercial fuels like LPG is still negligible in the rural areas with only 1.3% households using the fuel for cooking (TERI 1998a). On the other hand, biomass use continues to increase. The monthly per capita consumption of firewood increased from 16 kg to 17 kg over the period 1987/88 to 1993/94 (Figure 5). The Planning Commission estimates the fuelwood requirement at 180 million tonnes in 2001, a substantial increase from the actual consumption of 162 million tonnes in 1996 (Ninth Five-Year Plan: 1997-2002). As Figure 6 shows, the use of firewood in the form of logs has tripled in 15 years. The share of firewood

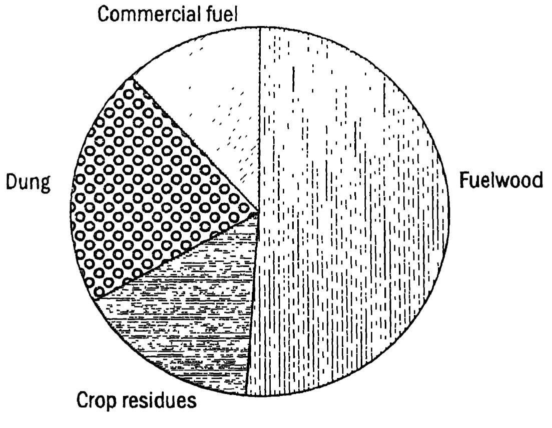


Figure 4 Energy use in the rural domestic sector
Source Natarajan (1985)

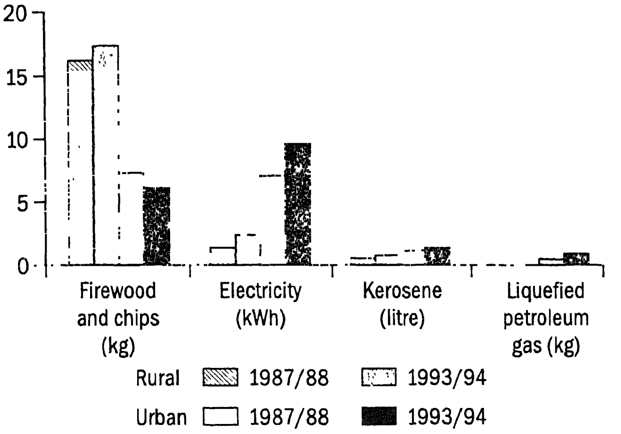


Figure 5 Monthly per capita fuel consumption
Source NSSO (1997b)

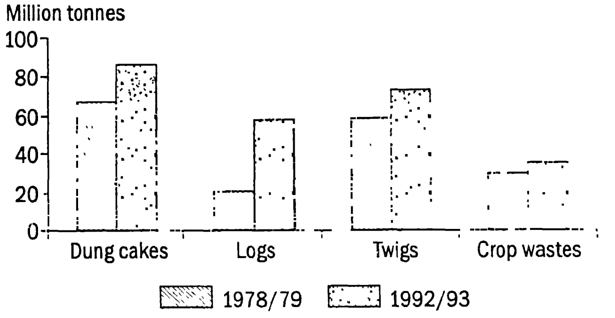


Figure 6 Energy consumption in rural households
Source Natarajan (1997)

(percentage of households using a particular fuel) in the form of twigs fell from 67.6% in 1978/79 to 62.9% in 1992/93; during the same period, the share of firewood in the form of logs rose dramatically from 18.95% to 32.49% (Agarwal 1998). A definite shift from other fuels to firewood has also been observed.

The energy consumption pattern varies considerably across different states and districts because of the geographical and ecological diversity in the country. For instance, the consumption of fuelwood ranges from 2.04 kg per household per day in Haryana to 14.14 kg per household per day in Orissa (TERI 1995). The fuel mix also varies from region to region depending on the resource endowments. Fuelwood consumption is high in states that have considerable forest cover; for instance, in Arunachal Pradesh it is 10.4 kg per household per day and in Manipur it is 10.34 kg per household per day. On the other hand, consumption of dung cakes is high in states like Uttar Pradesh (4.95 kg per household per day) and Rajasthan (3.41 kg per household per day) that have little biomass cover (TERI 1995). Crop residue, being inferior in quality, is used in most areas as a back-up fuel when there is a shortage of other fuels.

The energy consumption pattern in rural areas is determined by the availability of biomass resources, people's access to these resources, their competing uses, and availability of commercial energy sources. Other factors that do not strictly fall within the energy system, but play a crucial role in determining people's choices regarding fuels, include income levels, purchasing power, and accessibility to urban centres.

There has also been a major shift in household consumption expenditure, which is indicative of the lifestyle changes. Most households in the higher MPCE class level use less of firewood and chips as their primary energy source for cooking. However, the percentage of households in all MPCE levels in the rural areas using dung cake as the primary source of energy for cooking remains constant as domestic cattle is maintained by these households (NSSO 1997a). In 1978/79, one-third of the households was purchasing firewood logs, while in 1992/93, just about one-sixth was doing so (Agarwal 1998). The 50th round of the NSS (National Sample Survey) found that only two per cent of rural households could afford to use kerosene or gas as the primary source of energy for cooking (NSSO 1997a).

Rural-urban disparity

An issue of concern is the disparity that exists in the energy use between the rural and urban households. The rural–urban disparity exists in the type of fuels and cooking devices used and in the quantum of energy use. While the monthly per capita consumption of firewood and chips has increased in rural areas, it declined in urban areas between 1987/88 and 1993/94 (Figure 5).

In the rural areas, the shift to commercial fuels has been marginal. For instance, only one per cent of the households in the rural areas has switched over from firewood and chips as a source of cooking since 1987/88 (NSSO 1997a). While the dependence of rural households on dung cake, coke, and coal has fallen and that on kerosene and gas has risen over successive NSS rounds, the percentage of households (77–79) dependent on firewood and chips has remained constant (NSSO 1997a). The Rural Electrification Programme, which is the largest rural energy programme in India today, claims to have electrified more than 85% of the 580 000 villages in the country (CEA 1996). But, only 37% of the rural households has electricity connections compared to 83% urban households (NSSO 1997a). On the other hand, during 1983 to 1993/94, the use of electricity for lighting rose by 22% in rural areas as against an increase of 19% in urban areas. However, taking total figures, the rural–urban divide is still wide. As against 27.2% of the urban households, only 1.3% of the rural households use LPG for cooking (CMIE 1996a). A similar disparity exists in the case of kerosene, which is promoted predominantly as a subsidized fuel for the poor. According to the 1991 census, while 23.62% urban households use kerosene as a cooking fuel, only 1.34% rural households use kerosene for cooking (CMIE 1996b). The percentage of households using kerosene as the primary source of energy decreased from 74 to 62 in the rural areas and from 27 to 16 in the urban areas between 1983 and 1993/94 (NSSO 1997a).

Impacts of over-dependence on traditional fuels

The over-dependence on traditional fuels has led to several ecological and health problems. Though no direct correlation between deforestation and fuelwood use in the rural areas has been established, fuelwood extraction could exacerbate the process where the land is already degraded (TERI 1996a). Of the total requirement of 200 million tonnes, 102 million tonnes is expected to be met from forest areas and 98 million tonnes from farm forestry. It is estimated that about 18 million tonnes is available as fuelwood annually on a sustainable basis from the forests. This means that the remaining requirement of 84 million tonnes is to be met by excessive removal from forest areas, putting severe stress on our forest resources (Ninth Five-year Plan: 1997–2002). Loss of green cover and burning of biomass in inefficient traditional cookstoves significantly contribute to greenhouse gas emissions. In India, it is estimated that of the 68.3 million tonnes of carbon released annually due to biomass burning, fuelwood accounts for 82.3% (Kaul 1993). Wood burning also produces products of incomplete combustion, which have a global warming potential of 20%–110% as much as carbon dioxide itself (Smith 1992).

The use of agricultural residues and animal dung as energy sources instead of fertilizers reduces the soil nutrient level. It has been estimated that out of the total nitrogen content of dung production of 1.35 million tonnes annually, 0.4 million tonnes is lost annually through the burning of dung as fuel (Ravindranath and Hall 1995).

The use of biomass fuels has several human costs attached to it, which go far beyond economics. Due to increasing shortages, women are being forced to spend more time and walk longer distances to collect fuelwood (Agarwal 1986, 1991). The burden of carrying large head-loads of wood over long distances is known to cause ailments such as muscular pains, backache, and pregnancy-related problems. Further, the burning of biomass in inefficient and poorly vented appliances is a serious health hazard for women and children (Smith 1993). In a study conducted by TERI in the Garhwal Himalayas, the measured mean daily exposure of women (due to cooking) to TSP (total suspended particulate) was found to be as high as 17 mg-h/m^3 (Saksena, Prasad, Pal, et al. 1992). In the Delhi slums, which represent similar indoor environment in terms of the device and the fuel used, TERI found that the exposure of infants (0–12 months) to RSP (respirable suspended particulate) was 5 to 77 times more than the WHO (World Health Organisation) standards for PM10 (particulate matter less than 10 mm) (TERI 1996b).

Yet another social dimension of the problem is that of head-loading. As fuelwood becomes scarcer for both rural and urban poor, head-loading serves as a regular source of livelihood for a large number of rural poor. This increases the tendency to exploit biomass resources. Estimate shows that 2 to 3 million people are engaged in head-loading as a regular profession, supplying fuelwood to urban markets (CSE 1985).

Use of commercial fuels in rural domestic sector

Petroleum products like LPG and kerosene form less than two per cent of the total energy consumption in the rural areas (Figures 7 and 8). Hence the large imports of petroleum products only marginally benefit the rural populace that constitute nearly 70% of the population in the country.

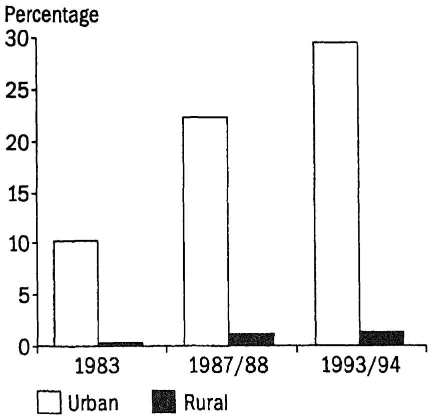


Figure 7 Households using liquefied petroleum gas for cooking
Source NSSO (1997a)

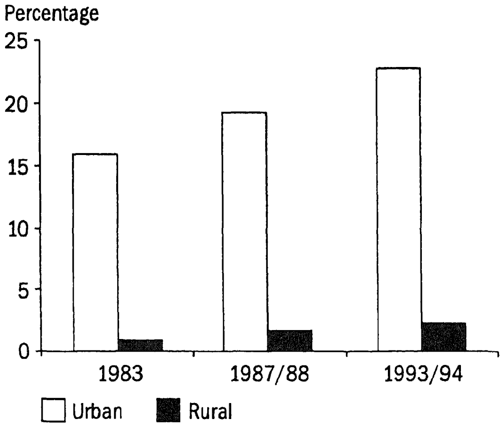


Figure 8 Households using kerosene for cooking
Source NSSO (1997a)

Kerosene

In rural India, kerosene is mainly used for lighting. According to the 50th round of NSS (NSSO 1996), around 62% of the rural households use kerosene primarily for lighting. Only two per cent of the rural households in India used kerosene as the primary cooking fuel. The total kerosene consumption in India during 2000/01 was estimated at around 10.5 million tonnes out of which about 60% was for the rural areas.

In India, two systems exist for the supply of kerosene to the households i.e. PDS (public distribution system) at subsidized rates and the parallel marketing system at the market determined prices. Supply of kerosene through the PDS is the main source of supply for rural consumers. The main steps involved in the process are as follows (Figure 9).

- Quota of each state fixed by the MoPNG (Ministry of Petroleum and Natural Gas), Government of India.
- Monthly allocation along with oil companywise break-up, communicated to the states through the OCC (Oil Coordination Committee).
- The Food and Civil Supplies Authorities of each state on receipt of advice from the OCC decide on
  - districtwise allocation,
  - retailerwise allocation,
  - decide on quota per ration card/rationing unit, and
  - ensure smooth and steady distribution of kerosene within the state.

- Oil companies make available the kerosene to their depots, from where the wholesaler under the direction of the Food and Civil Supplies Authority lifts the quota.

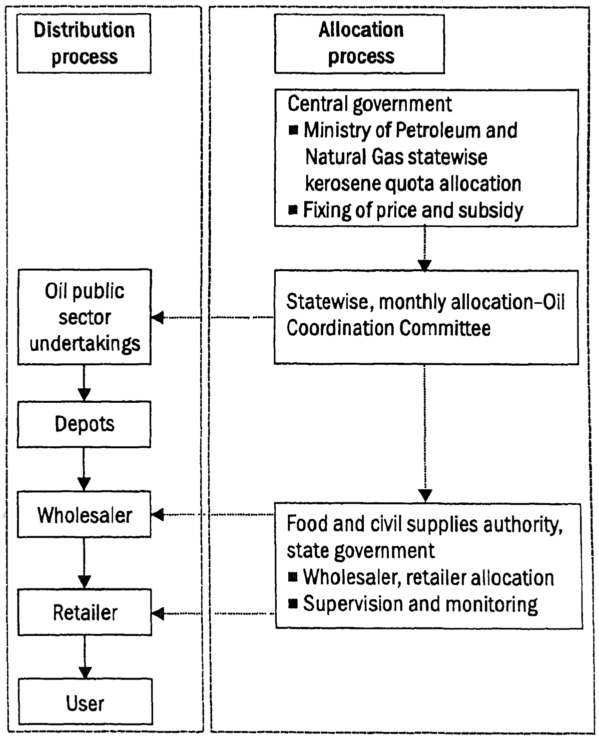

Distribution process
Allocation process
Central government
■ Ministry of Petroleum and Natural Gas statewise kerosene quota allocation
■ Fixing of price and subsidy
Oil public sector undertakings
Statewise, monthly allocation-Oil Coordination Committee
Depots
Wholesaler
Food and civil supplies authority, state government
■ Wholesaler, retailer allocation
■ Supervision and monitoring
Retailer
User

Figure 9 Allocation and distribution of kerosene
Source MoPNG: Personal Communication

- Wholesaler delivers the kerosene to retailers as per the allocation of the Food and Civil Supplies Authority.

During 2000/01, the supply was around 10.5 million tonnes. The PCA (per capita allocation) for states ranges between 10 and 24 kg a year. During the period 1993/94 to 1997/98, the government provided a three per cent growth annually at the national level. The additional quantity available at the national level was allocated to the states/ union territories based on the principle of higher growth rate to the states, having lower PCA. It was decided by the government that no growth from the year 1999/2000 onwards would be allowed in the PDS kerosene supply, keeping in view the high LPG enrollment during the last few years and switching over of kerosene consumers to LPG. While allocating kerosene for the year 1999/2000, the maximum PCA has been frozen at 24 kg a year (MoPNG 2000).

On the other hand, under the APM (administered pricing mechanism), a private party can import kerosene after obtaining a rating certificate from one of the approved rating agencies given in the Kerosene (restriction on use of fixation of ceiling price) Order, 1993, of the MoPNG, Government of India, as amended from time to time. These products are to be sold at market-determined prices by the private parties through their own distribution network.

At the all-India level, up to 1 January 2000, 5615.4 million tonnes of kerosene has been imported by the private sector under the scheme. The quantity of kerosene marketed under the parallel marketing scheme in 1999/2000 accounted for just about 10% of the total kerosene consumption in the country. The contribution of kerosene through parallel marketing in rural areas, therefore, remains to be very small (MoPNG 2001a).

Liquefied petroleum gas

Four public sector undertakings, namely the Bharat Petroleum Corporation Ltd, the Hindustan Petroleum Corporation Ltd, the IBP Company Ltd, and the Indian Oil Corporation Ltd are engaged in the marketing of LPG in the country. With the increased availability of LPG, the number of LPG customers enrolled by them has also been increasing. Since 1985, the consumption of LPG has grown from over 100 million tonnes in 1985 to over 6000 million tonnes in 1999. The number of LPG customers served by the four oil companies as on 1 January 2000 was 43.6 million (MoPNG 2000). However, the rural penetration during this period is just over one per cent of the total households (MoPNG 2000). It is also estimated that in the next decade there is going to be a rapid increase in the consumption of LPG. It may be noted that a large portion of the over 100% increase in the estimated consumption is going to be in the rural areas. This is due to the fact that with the increasing non-availability of traditional fuels, and LPG being a convenient and safe cooking fuel, the government has decided to commence marketing of LPG in the rural areas. Further, with a view to penetration into the rural areas, the MoPNG has approved a special scheme in July 1999 for release of new LPG connections in the rural sector against the surrender of corresponding kerosene quota through the following moves.

- Opening of extension counter in rural areas falling within 15 km radius of the normal trading area of the existing distributors operating in the urban areas.
- Award of interim LPG distributorships to the state civil supplies corporation or the concerned state government body till a regular distributor is approved (MoPNG 2000).

The government in November 1997 decided to dismantle the APM in a phased manner. Under this, the subsidy on domestic LPG was brought down to 15% during the year 2000/01 (Table III).

In spite of the fact that LPG has been around for a number of years, it has not penetrated the rural areas of the country. In the wake of the

Table III Estimated subsidy on LPG based on May 2000 price

	LPG (Rs/cylinder)
Ex-storage point price	154.01
Import parity price based on ex-storage point price	297.09
Subsidy	143.08
Subsidy (%) of the import parity price	48.16 %

Source MoPNG (2001b)

initiation of the deregulation process, it is necessary to ascertain the factors that will promote the access of LPG to the rural poor.

The continued subsidy on LPG has basically hampered the growth of the parallel market and, thereby, adversely affected the penetration in rural areas. On the other hand, the issue of low-income levels in rural areas is responsible for low buying capacities of the rural communities. Hence, while dismantling the APM, it would be crucial to evolve mechanisms for the provision of easy credit to the rural masses.

In order to increase the availability of LPG, the private sector was allowed to participate at the schemes of parallel marketing of LPG since April 1993. Under the scheme, a private party can undertake the import of LPG after obtaining a rating certificate from one of the approved rating agencies given in the LPG (Regulation of Supply and Distribution) Order, 1993, as amended from time to time. These products are to be sold at market-determined prices by the private parties through their own distribution network. Up to 1 January 2000, 695.1 million tonnes of LPG has been imported by the private sector under the scheme (MoPNG 2000).

People are not shifting to LPG as fuelwood is cheap and easily available and there is fear that LPG is a dangerous fuel. In most of the companies, the policy is that the cylinders will be refilled after 21 days. However, owing to logistic and economic reasons, rural customers usually take 3 months to get the cylinders refilled. It is important to assess the specific modalities for increasing the rural coverage of LPG. This would require a focus on determining the infrastructure requirement, cost-benefit analysis of investment, strategy for raising awareness, and assessing and customizing according to the needs of the local communities.

References

Agarwal A. 1998
False predictions
Down to Earth 7(1): 29–39

Agarwal B. 1986
Cold hearths and barren slopes: the wood fuel crisis in the third world
New Delhi: Allied Publishers. 209 pp.

Agarwal B. 1991
Engendering the environment debate: lessons from the Indian subcontinent
Submitted to Centre for Advanced Study of International Development, Michigan State Univiersity, USA
[CASID Distinguished Speaker Series No. 8]

Bhatia R. 1988
Energy pricing and household energy consumption in India
The Energy Journal 9 (Special Issue)

CEA (Central Electricity Authority). 1996
General Review 1993/94
New Delhi: CEA

CMIE (Centre for Monitoring Indian Economy). 1996a
India's Energy Sector.
Mumbai: CMIE. 323 pp.

CMIE (Centre for Monitoring Indian Economy). 1996b
India's Social Sectors.
Mumbai: CMIE. 290 pp.

CSE (Centre for Science and Environment). 1985
The State of India's Environment 1984–85: The Second Citizen's Report
New Delhi: CSE. 394 pp.

Kaul O N. 1993
Forest biomass burning in India
In *The Climate Change Agenda: An Indian Perspective*
edited by A N Achanta
New Delhi: TERI. 305 pp.

MoPNG (Ministry of Petroleum and Natural Gas). 2000
Annual Report 1999/2000
New Delhi: MoPNG, Government of India.

MoPNG (Ministry of Petroleum and Natural Gas). 2001a
http://www.petroleum.nic.in
(Accessed on 23 January 2001)

MoPNG (Ministry of Petroleum and Natural Gas). 2001b
http:/www.petroleum.nic.in
(Accessed on 20 June 2001)

Natarajan I. 1985
Domestic fuel survey with special reference to kerosene (Volume I)
New Delhi: National Council for Applied Economic Research. 296 pp.

Ninth Five Year Plan: 1997-2002
Volume II. Thematic Issues and Sectoral Programmes
New Delhi: Planning Commission. Government of India, 1059 pp.

NSSO (National Sample Survey Organization). 1995
Household consumer expenditure and employment situation in India, 1994/95
New Delhi: NSSO, Department of Statistics, Government of India. [Report no. 436.]

NSSO (National Sample Survey Organization). 1996
Key Results on Household Consumer Expenditure, 1993/94
New Delhi: NSSO, Department of Statistics, Government of India. [Report No. 401.]

NSSO (National Sample Survey Organization). 1997a
Energy used by Indian households
Fifth Quinquennial Survey on Consumer Expenditure. NSS 50th round (July 1993–June 1994)
Kolkata: NSSO, Department of Statistics, GOI. 93 pp. [Report No. 410.]

NSSO (National Sample Survey Organization). 1997b
Consumption of some important commodities in India
New Delhi: NSSO, Department of Statistics, Government of India. [Report No. 404.]

Planning Commission. 1985
Evaluation report on essential supplies programme
New Delhi: Plan Evaluation Organization, Planning Commission, Government of India.

Ravindranath N H and Hall D O. 1995
Biomass, Energy, and Environment: Developing Country Perspective from India
Oxford: Oxford University Press.

Saksena S, Prasad R, Pal R C, Joshi V. 1992
Patterns of daily exposure to TSP and CO in the Garhwal Himalaya
Atmospheric Environment **26A**(11): 2125–2134

Smith K R. 1992
Biomass cookstoves in global perspectives: energy, health, and global warming
In *Indoor Air Pollution from Biomass Fuel*
Geneva: World Health Organization
[Working papers from a World Health Organization Consultation WHO/REP/92 3B, WHO]

Smith K R. 1993
Fuel combustion, air pollution exposure and health: the situation in developing countries
Annual Review of Energy and Environment **18**: 529–56

TERI (Tata Energy Research Institute). 1995
Environmental Considerations and Options in Managing India's Long-term Energy Strategy (Eco Miles)
New Delhi: TERI. 281 pp.

TERI (Tata Energy Research Institute). 1996a
Rural energy sector in India
Submitted to the Royal Danish Embassy, New Delhi
New Delhi: TERI

TERI (Tata Energy Research Institute). 1996b
Environment of urban poor communities in Asia: study on effects of indoor air pollution among infants in Delhi and Manila
Submitted to the European Commission
New Delhi: TERI

TERI (Tata Energy Research Institute). 1998a
TEDDY (TERI Energy Data Directory & Yearbook 1998/99)
New Delhi: TERI. 348 pp.

TERI (Tata Energy Research Institute). 1998b
Looking Back to Think Ahead. p.35
New Delhi: TERI

Table 2.87 Urban population and settlements in India: 1901 to 1991 (census years)

Census year	*All classes*	*Class*[a] (% of population)						*Total urban population* (million)	*Urban to total population* (%)
		I	*II*	*III*	*IV*	*V*	*VI*		
1901	100	26	11.3	15.6	20.83	20.14	6.1	25.85	10.84
	(1811)	(24)	(43)	(130)	(391)	(744)	(479)		
1911	100	27.48	10 5	16.4	19.73	19.31	6.57	25.94	10.29
	(1754)	(23)	(40)	(135)	(364)	(707)	(485)		
1921	100	29.7	10.4	15.9	18.29	18.67	7.03	28.08	11.18
	(1894)	(29)	(45)	(145)	(370)	(734)	(571)		
1931	100	31.2	11.7	16.8	18	17.14	5 21	33.45	11.99
	(2017)	(35)	(56)	(183)	(434)	(800)	(509)		
1941	100	38.23	11.4	16.4	15.78	15.08	3.14	44.15	13.86
	(2190)	(49)	(74)	(242)	(498)	(920)	(407)		
1951	100	44.63	9.96	15.7	13.63	12.97	3.09	62.44	17.29
	(2795)	(76)	(91)	(327)	(-608)	(1124)	(569)		
1961	100	51.42	11.2	16.9	12.77	6.87	0.77	78.93	17.97
	(2270)	(102)	(129)	(437)	(719)	(711)	(172)		
1971	100	57.24	10.9	16	10.94	4.45	0.44	109.11	19.91
	(2476)	(148)	(173)	(558)	(827)	(623)	(147)		
1981	100	60.42	11.6	14.3	9.54	3.58	0.5	159.46	23.34
	(3245)	(216)	(270)	(738)	(1053)	(739)	(229)		
1991	100	65.2	11	13.2	7.77	2.6	0.29	217.17	25.72
	(3609)	(296)	(341)	(927)	(1135)	(725)	(185)		

[a] Census of India classifies a town according to population size, which are as follows: Class I 100 000 and above; Class II 50 000-99 999; Class III 20 000-49 999; Class IV 10 000-19 999; Class V 5 000-9 999; and Class VI Less than 5 000.

Note

Figures in parentheses are the number of settlements in each class size.

Source

Census of India. 1991. [Statement 14 and 17], p. 30 and p. 32. New Delhi: Registrar General and Census Commissioner, Ministry of Home Affairs. [Paper 2 of 1991, Provisional population totals: rural-urban distribution.]

Table 2.88 Consumer's monthly per capita expenditure (%) on fuel and light

State	*32nd round NSS (July 1977-June 1978)*		*38th round NSS (January-December 1983)*		*43rd round NSS (July 1987-June 1988)*		*50th round NSS (1993/94)*	
	Rural	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*
Andhra Pradesh	5.22	5.54	5.96	6.04	6.24	5.90	5.94	6.13
Assam	7.32	5.59	7.91	7.18	8.01	24.87	7.69	5.84
Bihar	5.44	5.41	6.68	6.48	7.63	6.67	7.73	7.05
Gujarat	5.81	5.75	7.22	6.97	8.16	8.26	7.74	7.11
Haryana	4.50	5.37	6.53	6.87	6.37	6.93	5.91	6.70
Himachal Pradesh	8.16	7.20	8.96	6.50	21.25	6.79	7.77	4.29
Karnataka	6.67	6.47	8.22	7.04	8.64	7.37	8.09	7.41
Kerala	5.60	6.14	5.82	5.70	6.40	6.02	5.74	5.54
Madhya Pradesh	5.92	3.57	6.99	7.17	7.60	6.42	9.73	6.54
Maharashtra	5.05	6.08	8.30	6.92	7.53	6.54	7.38	6.78
Orissa	6.81	5.53	5.88	6.84	9.07	7.13	9.23	7.43
Punjab	5.79	5.52	6.82	8.10	7.25	7.61	7.74	7.65
Rajasthan	4.07	5.65	7.50	6.74	7.28	6.27	8.29	6.80
Tamil Nadu	6.40	6.50	6.75	6.29	6.70	6.10	5.99	6.38
Uttar Pradesh	5.83	6.11	7.84	8.00	7.69	7.55	6.95	7.09
West Bengal	5.74	5.40	6.64	6.68	7.34	7.47	7.05	7.27
All-India	5.56	5.71	7.08	6.82	7.44	6.69	7.35	6.60

Sources

1 National Sample Survey Organization. 1991. *Sarvekshana* XIV - 3 (46) (January-March 1991). (For July 1977-June 1978 and January-December 1983)

2 National Sample Survey Organization. 1991. *Sarvekshana* XV - 1 (48) (July-September 1991). (For July 1987-June 1988)

3 National Sample Survey Organization. 1996. *Sarvekshana* XIX - 3 (66) (January-March). (For 1993/94)

Table 2.89 Households having electricity connection (%): 1981 and 1991

State / Union Territory	*1981*			*1991*		
	Total	*Rural*	*Urban*	*Total*	*Rural*	*Urban*
State						
Andhra Pradesh	21.41	12.53	52.22	46.30	37.50	73.31
Arunachal Pradesh	15.15	10.99	64.26	40.85	33.88	80.96
Assam	0	0	0	18.74	12.44	63.21
Bihar	9.20	3.48	50.90	12.57	5.57	58.77
Delhi	73.57	51.68	74.94	79.48	59.85	81.38
Goa	58.08	52.52	69.97	84.69	81.82	88.77
Gujarat	44.81	30.83	74.40	65.93	56.43	82.96
Haryana	51.53	41.04	82.22	70.35	63.20	89.13
Himachal Pradesh	54.86	51.08	89.36	87.01	85.86	96.24
Jammu and Kashmir	60.87	52.24	92.18	0	0	0
Karnataka	32.98	21.35	91.98	52.47	41.75	76.27
Kerala	28.78	23.21	54.57	48.43	41.95	67.65
Madhya Pradesh	17.11	6.89	56.42	43.30	34.49	72.52
Maharashtra	40.65	24.12	70.53	69.40	58.45	86.07
Manipur	20.06	10.28	48.32	50.92	41.73	75.45
Meghalaya	16.84	7.44	59.59	29.16	16.34	83.04
Mizoram	16.27	4.96	50.06	59.20	35.47	85.50
Nagaland	26.12	19.97	58.43	53.42	47.16	75.58
Orissa	17.75	13.03	51.74	23.54	17.45	62.11
Punjab	60.90	50.61	85.44	82.31	76.98	94.60
Rajasthan	20.54	8.70	63.67	35.03	22.44	76.67
Sikkim	23.11	13.01	71.80	60.66	57.12	92.37
Tamil Nadu	37.21	26.03	61.59	54.74	44.49	76.80
Tripura	25.05	16.52	92.10	36.93	28.50	80.43
Uttar Pradesh	12.91	3.97	54.61	21.91	10.96	67.76
West Bengal	21.09	7.02	57.86	32.90	17.75	70.19
Union Territory						
Andaman and Nicobar Islands	35.92	19.87	78.22	63.52	53.62	90.55
Chandigarh	84.43	67.85	85.48	83.12	65.25	85.48
Dadra and Nagar Haveli	28.66	25.87	67.66	54.42	51.20	87.57
Daman and Diu	78.33	73.48	85.89	94.13	92.87	95.46
Lakshadweep	91.79	88.01	96.35	98.46	97.65	99.11
Pondicherry	43.79	28.97	58.11	63.58	51.20	71.71
India	26.19	14.69	62.51	42.37	30.54	75.78

Source

GoI. 1995. **Housing and amenities**. Occasional Paper No. 5 of 1994. ***Census of India 1991***. New Delhi: Office of the Registrar General and Census Commissioner, Government of India.

Table 2.90 All-India purchases of durable products (**million**) (rural and urban): 1985/86 to 1995/96

Product	*1985/86*	*1989/90*	*1992/93*	*1993/94*	*1994/95*	*1995/96*
Bicycle	4.700	5.692	7.078	8.131	7.500	8.016
Cassette recorder	1.300	3.430	5.450	5.880	6.466	6.991
Electric iron	1.300	1.600	2.000	2.360	2.614	2.885
Fan (ceiling)	3.080	2.500	4.710	5.210	6.025	7.085
Fan (table)	1.700	1.300	2.260	5.740	3.150	3.196
Geyser (instant)	0	0.120	0.168	0.126	0.180	0.196
Geyser (storage)	0	0.077	0.084	0.249	0.265	0.321
Mixer/grinder	0.800	1.500	1.680	1.750	1.850	1.974
Motorized two wheeler (moped)	0.429	0.500	0.405	0.449	0.545	0.716
Motorized two wheeler (motor cycle)	0.199	0.340	0.358	0.436	0.454	0.535
Motorized two wheeler (scooter)	0.480	0.718	0.730	0.840	0.901	1.217
Pressure cooker	2.200	3.100	3.390	0.326	3.501	3.980
Pressure pan	–[a]	–[a]	–[a]	0.264	0.308	0.388
Radio / transistor	3.200	5.000	4.730	4.490	4.935	5.400
Refrigerator	0.560	1.090	1.190	1.470	1.608	1.995
Sewing machine	0.980	0.500	0.550	0.590	0.650	0.719
Television (black and white)	1.400	4.000	3.390	3.900	4.645	5.988
Television (colour)	0.600	1.200	0.830	1.280	1.392	1.747
Video cassette recorder / video cassette player	0.080	0.420	0.130	0.150	0.186	0.204
Washing machine	0.110	0.290	0.520	0.790	0.970	1.134
Wrist watch (mechanical)	6.200	10.900	10.890	10.560	8.397	9.018
Wrist watch (quartz)	2.500	7.300	7.850	8.020	8.743	10.242

[a] included under pressure cooker

Source

Natrajan I. 1998. **India market demographics report 1998**. New Delhi: National Council for Applied Economic Research.

Table 2.91 Purchases of durable products (rural share) (%): 1985/86 to 1995/96

Product	*1985/86*	*1989/90*	*1992/93*	*1993/94*	*1994/95*	*1995/96*
Bicycle	82.00	73.82	78.09	77.75	78.95	78.08
Cassette recorder	47.00	42.77	49.06	53.45	54.75	55.03
Electric iron	46.00	43.00	34.45	42.18	43.81	43.45
Fan (ceiling)	46.00	45.00	46.10	48.09	48.97	50.36
Fan (table)	60.73	58.00	60.78	64.98	64.55	65.89
Geyser (instant)	0	1.60	0.15	0.87	2.62	2.04
Geyser (storage)	0	2.58	4.31	0.95	1.49	1.55
Mixer/grinder	18.00	21.00	23.16	24.57	26.93	27.43
Motorized two wheeler (moped)	42.00	42.94	39.59	41.53	42.03	39.27
Motorized two wheeler (motor cycle)	52.00	51.00	47.66	49.09	47 54	47.87
Motorized two wheeler (scooter)	36.00	27.74	27.83	29.50	32.71	28.56
Pressure cooker	34.00	37.00	45.14	46.13	51.28	51.51
Pressure pan	–[a]	–[a]	–[a]	17.98	15.50	19.45
Radio / transistor	79.00	78.39	79.43	78.61	78.74	79.20
Refrigerator	14.00	15.00	18.07	20.15	24.38	24.30
Sewing machine	60.00	56.00	63.72	64.29	66.40	64.34
Television (black and white)	26.00	44.00	47.70	57.11	59.44	62.65
Television (colour)	11.00	19.00	31.10	30.90	31.72	28.77
Video cassette recorder / video cassette player	4.85	4.58	7.82	7.98	10.31	24.87
Washing machines	12.00	7.00	9.93	12.30	14.02	14.64
Wrist watch (mechanical)	78.00	71.00	72.14	76.10	76.64	75.59
Wrist watch (quartz)	59.00	47.00	51.57	50.30	52.08	54.00

[a] included under pressure cooker

Source

Natrajan I. 1998. **India market demographics report 1998**. New Delhi: National Council for Applied Economic Research.

Table 2.92 Distribution of households (rural and urban) by fuel used (%): 1974 to 1991

	Rural				*Urban*			
Fuel	*1974*	*1979*	*1991*[a]	*1991*[b]	*1974*	*1979*	*1991*	*1991*
Coal/soft coke	–	3.51	1.54	–	26.6	28.0	8.95	–
Kerosene	6.8	6.10	1.34	–	10.9	40.0	23.62	–
Firewood	64.2	35.10	71.69	–	47.0	40.0	32.74	–
Liquefied petroleum gas	0.8	1.10	1.22	–	4.0	10.0	26.93	–
Biogas	–	1.00	0.43	–	–	–	0.68	–
Electricity	–	14.30	0.16	30.54	–	63.4	0.72	75.78
Cow dung	–	59.10	19.60	–	–	26.6	3.51	–

[a] fuel used by households only for cooking

[b] households having electricity connection

Sources

1 NCAER. 1981. **Domestic fuel survey with special reference to kerosene (1978/79)**. New Delhi: National Council for Applied Economic Research.

2 GoI. 1979. **National Sample Survey 1973/74, 28th round. Report of the Working Group on Energy Policy**. New Delhi: Government of India.

3 GoI. 1995. **Housing and amenities**. Occasional Paper No. 5 of 1994. ***Census of India 1991***. New Delhi: Office of the Registrar General and Census Commissioner, Government of India.

For more details, please see TEDDY ONLINE+ [Section: Residential (general)]

Table 2.93 Rural households by primary source of energy for cooking for each MPCE (monthly per capita expenditure) class (%)

MPCE class (Rs)	*No cooking arrangement*	*Coke and coal*	*Firewood and chips*	*Gas (coal, oil or LPG[a])*	*Gobar gas*	*Dung cake*	*Charcoal*	*Kerosene*	*Others*	*All*
Less than 120	1.4	0.7	79.1	0.1	0.1	10.1	–	–	8.6	–
121-140	0.4	0.7	80.9	0.2	–	12.3	–	–	5.5	–
141-185	0.3	0.9	81.0	0.1	–	12.2	–	0.2	5.2	–
186-190	0.3	1.1	82.1	0.1	0.1	11.2	–	0.6	4.6	–
191-210	0.6	0.9	81.1	0.4	0.1	11.9	–	0.5	4.4	–
211-235	0.4	1.0	81.8	0.3	0.1	11.7	–	0.9	3.9	–
236-265	0.4	1.4	81.4	0.5	0.2	11.7	–	0.9	3.5	–
266-300	0.2	1.6	80.2	1.1	0.3	11.7	–	1.3	3.5	–
301-355	0.6	1.7	79.9	1.3	0.4	10.8	–	2.2	3.0	–
356-455	1.1	1.7	75.0	2.9	0.7	12.2	0.1	3.7	2.5	–
456-560	0.8	2.0	71.6	8.0	1.0	11.3	–	4.8	2.2	–
561 and above	2.8	2.0	58.2	12.4	1.2	11.0	0.1	10.1	2.2	–
All classes	0.7	1.4	78.2	1.9	0.3	11.5	–	2.0	3.8	–
Estimated households (hundreds)	8335	16 186	934 591	22 665	4048	137 840	433	24 386	45 849	1 194 669
Sample households	373	918	54 892	1976	385	7 056	29	1 437	2 117	69 206

[a] liquefied petroleum gas

Source

NSSO. March 1997. **Energy used by Indian households.** New Delhi: National Sample Survey Organization, Department of Statistics, Government of India. [Report No. 410/2.]

Table 2.94 Urban households by primary source of energy for cooking for each MPCE (monthly per capita expenditure) class (%)

MPCE class (Rs)	*No cooking arrangement*	*Coke and coal*	*Firewood and chips*	*Gas (coal, oil* or LPG[a])	*Gobar gas*	*Dung cake*	*Charcoal*	*Kerosene*	*Others*	*All*
Less than 160	9.3	5.6	67.9	2.0	0.1	4.8	0.1	7.3	2.8	–
160-190	3.1	6.8	65.7	2.2	0	4.0	0	14.3	3.6	–
190-230	3.0	7.7	81.8	5.4	0	3.3	0.1	15.5	3.2	–
230-265	2.2	8.3	53.3	8.0	0	4.7	0.5	19.8	3.2	–
265-310	2.0	7.4	45.0	14.7	0.1	2.4	0.4	24.9	3.2	–
310-355	1.4	8.3	36.0	20.7	0.2	3.0	0.3	27.1	2.9	–
365-410	3.5	7.0	28.0	27.5	0	2.3	0.3	28.7	2.7	–
410-490	4.9	6.3	21.5	32.8	0.2	1.7	0.3	29.6	2.7	–
490-805	7.6	4.0	14.7	40.7	0	2.0	0.3	27.9	2.6	–
805-825	9.6	3.9	9.3	49.4	0.2	1.3	0.2	24.1	1.8	–
825-1065	13.3	2.2	4.9	53.7	0	1.0	0	23.0	1.7	–
1065 and above	16.4	1.5	3.3	60.5	0.2	0.6	0	15.9	1.2	–
All classes	6.3	5.7	29.9	29.5	0.1	2.4	0.2	23.2	2.6	–
Estimated households (hundreds)	27 134	24 627	129 175	128 065	408	10 175	1058	100 495	11 119	432 603
Sample households	2 030	2 479	14 144	15 414	43	1 005	144	9 886	973	46 148

[a] liquefied petroleum gas

Source

NSSO. 1997. **Energy used by Indian households**. New Delhi: National Sample Survey Organization, Department of Statistics, Government of India. [Report No. 410/2.]

Table 2.95 Consumption of fuel in rural areas (states) (**rupees**): 1983/84 and 1993/94

State	*Traditional*				*Commercial*					
	Firewood and chips		*Dung cake*		*Kerosene*		*Liquefied petroleum gas*		*Electricity*	
	1983/84	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*
Andhra Pradesh	4.48	10.51	0.42	0.37	1.11	2.37	0.03	0.40	0.31	2.60
Assam	6.55	14.29	0.03	0.59	1.83	2.94	0.02	0.21	0.10	0.96
Bihar	2.34	6.93	1.88	5.08	1.06	2.69	0.02	0.04	0.03	0.33
Gujarat	6.13	11.02	0.57	1.66	1.50	3.61	0.01	0.60	0.75	5.15
Haryana	3.23	7.47	3.40	5.63	1.10	1.80	0.01	0.52	0.85	6.01
Karnataka	7.13	14.35	0.39	0.82	1.33	2.75	0.04	0.29	0.32	2.19
Kerala	6.15	14.97	0.01	0.01	1.03	2.07	0.01	0.88	0.78	3.04
Madhya Pradesh	4.30	16.24	1.25	3.56	1.00	1.87	0.01	0.06	0.18	2.05
Maharashtra	5.79	9.75	0.83	1.29	1.40	2.95	0.05	0.56	0.55	3.66
Orissa	4.23	13.23	0.61	1.50	1.08	2.24	–	0.03	0.24	1.86
Punjab	4.27	8.88	3.89	8.76	1.07	2.74	0.02	0.92	1.51	10.51
Rajasthan	4.44	15.55	1.20	4.59	0.89	1.80	0.02	0.26	0.17	2.78
Tamil Nadu	5.42	10.36	0.19	0.19	1.09	3.07	0.01	0.69	0.55	2.69
Uttar Pradesh	3.32	7.94	3.24	6.45	1.01	2.52	0.01	0.20	0.05	0.85
West Bengal	2.84	7.85	0.97	3.51	1.21	3.11	0.02	0.05	0.10	0.81
All India	4.40	–	1.40	–	–	–	–	–	0.32	–

Source

NSSO. March 1997. **Energy used by Indian households**. New Delhi: National Sample Survey Organization, Department of Statistics, Government of India. [Report No. 410/2.]

Table 2.96 Consumption of fuel in urban areas (states) (**rupees**): 1983/84 and 1993/94

	Traditional				*Commercial*					
	Firewood and chips		*Dung cake*		*Kerosene*		*Liquefied petroleum gas*		*Electricity*	
State	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*	*1983/84*	*1993/94*
Andhra Pradesh	3.90	5.91	0.19	0.21	2.40	5.08	0.75	5.20	1.61	7.37
Assam	6.47	8.19	0.03	0.03	2.14	4.56	0.58	7.22	1.42	5.07
Bihar	1.86	3.25	0.72	1.89	1.30	3.82	0.25	3.55	0.96	6.06
Gujarat	1.98	2.78	0.21	0.49	3.34	5.87	1.06	7.28	2.95	14.49
Haryana	2.76	4.28	1.47	1.94	2.39	4.03	1.22	7.52	2.79	12.23
Karnataka	5.59	7.57	0.29	0.28	3.02	7.23	0.53	4.79	1.84	10.24
Kerala	5.59	14.05	0.02	0.01	1.21	2.62	0.75	3.73	1.84	5.58
Madhya Pradesh	4.25	6.57	0.45	1.08	1.73	3.58	0.61	5.90	1.65	7.80
Maharashtra	2.46	2.32	0.16	0.17	4.14	7.27	1.73	7.38	3.65	16.48
Orissa	6.03	9.56	0.20	0.38	1.25	4.20	0.24	4.09	1.48	9.27
Punjab	2.62	2.40	1.71	1.90	3.60	5.92	0.91	9.14	4.75	18.10
Rajasthan	4.56	7.24	0.83	1.65	1.93	4.04	0.27	4.93	1.70	9.63
Tamil Nadu	4.42	7.07	0.24	0.18	2.74	7.79	0.68	4.29	1.86	7.84
Uttar Pradesh	4.25	5.90	0.09	2.16	1.73	3.93	0.66	5.51	1.67	8.43
West Bengal	0.75	1.56	0.87	1.89	1.82	5.91	0.41	5.19	2.35	10.71
All India	3.45	–	0.53	–	2.54	–	0.85	–	2.29	–

Source

NSSO. March 1997. **Energy used by Indian households**. New Delhi: National Sample Survey Organization, Department of Statistics, Government of India. [Report No. 410/2.]

Table 2.97 Conversion efficiency of fuels used for cooking (%)

Fuel	*Efficiency*
Commercial	
Soft coke/coal	10
Kerosene (in pressure stoves)	40
Kerosene (in wick stoves)	36
Liquefied petroleum gas	60
Electric hotplates	71
Non-commercial fuels	
Firewood (closed hearth)	16
Firewood (open hearth)	13
Twigs and straw (closed hearth)	16
Twigs and straw (open hearth)	13
Charcoal	16
Dung cakes	8
Biogas stove	55

Sources

1 Data obtained from the Bureau of Indian Standards, New Delhi (1984).

2 Ravindranath N H and Ramakrishna J. 1997. **Energy options for cooking in India.** *Energy Policy* 25(1): 63–75.

Table 2.98 All-India estimates of commercial energy consumption in the domestic sector: 1980/81 to March 1997

Fuel	*1980/81*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*	*1995/96*	*1996*	*March 1997*
Liquefied petroleum gas[a] (million tonnes)[b]	0 33	1.89	2.13	2.28	2 42	2.76	3.09	2.45	3.36
Kerosene[c] (million tonnes)[b]	3.38	6.74	6.70	6.78	6.96	7.17	7.49	5.77	8.10
Electricity (GWh)	9247	31 982	35 923	39 717	43 344[d]	47 703	–	–	–

[a] liquefied petroleum gas (percentage share of domestic sector in total consumption): 80%

[b] estimated consumption based on the TERI study and the National Council for Applied Economic Research Survey

[c] provisional figure

[d] kerosene (percentage share of domestic sector in total consumption): 85%

Sources

1 MoPNG. 1997. ***Annual Report 1996/97***. New Delhi: Ministry of Petroleum and Natural Gas.

2 CEA. 1996. **Power Supply Industry in India. Highlights.** New Delhi: Central Electricity Authority.

Table 2.99 Annual per capita energy consumption in rural and urban areas: 1973/74 and 1978/79

Fuel	*Rural*		*Urban*	
	1973/74	*1978/79*	*1973/74*	*1978/79*
Commercial				
Coal/soft coke (kg)	6.8	2.3	33.4	31.30
Kerosene (litre)				
For lighting	0	4.3	0	2.60
For cooking[a]	0	0.8	0	9.00
Total	8.8	5.1	14.0	11.60
Liquefied petroleum gas (kg)	0	0.01	0	2.20
Electricity (kWh)	2.2	4.9	18.2	35.00
Traditional fuels (kg)				
Fuelwood	251.9	40.9	148.6	82.00
Charcoal	0.1	0.2	2.6	3.80
Dung cakes	72.7	133.1	25.2	35.70
Other solid fuels[b]	12.4	176.9	3.5	4.90

[a] also includes water heating and space heating

[b] includes crop wastes, sawdust, wood shavings, twigs, leaves, etc.

Sources

1 **Fuel Policy Commission Report**. 1974. New Delhi.

2 NCAER. 1981. **Domestic fuel survey with special reference to kerosene (1978/79)**. New Delhi: National Council for Applied Economic Research.

Table 2.100 Change in energy consumption in the household sector: 1970/71 and 1982/83

Fuel	*1970/71*	*1982/83*	*Change* (%)	*Composition* (%) *1970/71*	*Composition* (%) *1982/83*
Commercial					
Coal (million tonnes)	3.2	4.6	45.00	1.7	1.8
Oil (million tonnes)	3.7	5.7	55.00	4.0	4.6
Electricity (TWh)	3.8	12.0	211.00	0.4	0.8
Total (million tonnes of oil equivalent)	5.6	9.1	61.00	6.1	7.2
Non-commercial					
Firewood (million tonnes)	117.9	154.0	31.00	60.7	58.6
Crop residue (million tonnes)	36.3	40.0	10.00	16.4	13.5
Dung cake (million tonnes)	64.6	109.0	69.00	16.8	20.7
Total	86.5	115.8	34.00	93.9	92.8
Grand total (million tonnes of oil equivalent)	92.2	124.8	35.36	100.0	100.0

Sources

1 GoI. 1979. **Report of the Working Group on Energy Policy**. New Delhi: Government of India.

2 Planning Commission. 1985. **Report of the Advisory Board on Energy**. New Delhi: Planning Commission, Government of India.

Table 2.101 National aggregates of biofuel use in the rural domestic sector (**million tonnes per year**)

Source	*Firewood*	*Dung cake*	*Agricultural residue*
Consumption			
National Council for Applied Economic Research - 1985	93.3	83.2	36.7
Rural Energy Database (TERI) - 1992			
Low	181.3	40.1	31.6
Average	252.1	106.9	99.2
High	309.4	114.5	165.5
Integrated Rural Energy Programme - 1992	169.0	54.2	62.8
Requirement[a]			
Energy Survey of India (510 or 2.13) - 1965	151.3	41.5	47.8
Advisory Board on Energy (620 or 2.60) - 1985	240.5	65.9	76.0
Energy Demand Screening Group (520 or 2.18) - 1986	201.7	55.3	63.7

[a] in kcal/capita/day or in MJ/capita/day

Sources

1 Planning Commission. 1965. **Report of the Energy Survey of India Committee.** New Delhi: Planning Commission, Government of India.
2 Planning Commission. 1985. **Report of the Advisory Board on Energy.** New Delhi: Planning Commission, Government of India.
3 Planning Commission. 1986. **Report of the Energy Demand Screening Group.** New Delhi: Planning Commission, Government of India.
4 NCAER. 1985. **Domestic fuel survey with special reference to kerosene (1978/79).** New Delhi: National Council for Applied Economic Research.
5 TERI. 1992. **Rural Energy Database–India.** New Delhi: Tata Energy Research Institute.

Table 2.102 Daily per capita consumption of biofuels in rural households in different agroclimatic zones (kg): 1992

	Firewood		*Crop residue*		*Dung cake*	
Agroclimatic zones	*IREP*	*REDB - India*	*IREP*	*REDB - India*	*IREP*	*REDB - India*
Western Himalayas	1.95	1.09	0.1	–	0.22	0.17
Eastern Himalayas	1.70	1.90	–	0.37	–	0.20
Middle Gangetic plains	0.75	0.45	0.7	0.30	0.50	0.41
Upper Gangetic plains	0.36	0.29	0.4	0.04	0.43	1.29
Trans-Gangetic plains	0.37	0.38	1	0.34	0.65	0.57
Eastern plateau and hills	1.60	3.36	–	0.24	–	0.01
Western plateau and hills	0.79	0.94	0.4	0.50	0.47	0.18
Southern plateau and hills	0.62	0.94	0.3	0.82	0.19	0.25
East-coast plains and hills	0.60	1.78	0.1	1.35	0.13	0.91
West-coast plains and hills	1.29	0.94	0.2	0.12	–	0.16
Gujarat plains and ghats	0.92	0.87	0.3	0.31	0.22	0.23
Western dry region	1.08	0.57	–	0.13	0.44	0.61
Lower Gangetic plains	–	0.93	–	0.62	–	0.56
Central plateau and hills	–	0.95	–	0.26	–	0.65
All-India	–	1.22	–	0.47	–	0.40

IREP – Integrated Rural Energy Programme; REDB – Rural Energy Database - India

Sources

1 ***Eighth Five-year Plan, 1992–97.*** (Vol. 2). New Delhi: Planning Commission, Government of India.
2 TERI. 1992. **Rural Energy Database–India.** New Delhi: Tata Energy Research Institute.

Table 2.103 Energy consumption in rural households: 1978/79 and 1992/93

	1978/79		*1992/93*	
Energy fuel	*Quantity* (thousand tonnes)	*Share* (%) (useful kcal)	*Quantity* (thousand tonnes)	*Share* (%) (useful kcal)
Coal/soft coke	1 143	1.92	429	0.38
Kerosene	414[a]	2.55	1 103[a]	4.44
Dung cake	66 755	22.51	86 732	17.00
Firewood	–	–	–	–
Logs	20 109	11.95	57 956	32.49
Twigs	58 742	35.62	73 418	29.11
Crop waste	29 529	17.41	34 955	13.35
Others	–	1.03	–	–
Total	–	100.00	–	100.00

[a] in thousand kilolitres

Source

Natrajan I. 1997. **Biomass energy: key issues and priority needs.** Paris: Organization for Economic Cooperation and Development.

Table 2.104 Monthly per capita fuel consumption in rural areas (states): 1993/94

State	*Traditional*		*Commercial*	
	Firewood and chips (kg)	*Kerosene* (litre)	*Liquefied petroleum gas* (kg)	*Electricity* (kWh)
Andhra Pradesh	18.84	0.64	0.05	3.16
Assam	23.05	0.80	0.03	0.34
Bihar	10.39	0.60	0.01	0.13
Gujarat	14.61	1.14	0.08	4.78
Haryana	15.07	0.57	0.07	5.57
Karnataka	23.62	0.70	0.04	2.62
Kerala	23.57	0.70	0.12	4.29
Madhya Pradesh	27.33	0.52	0.01	1.89
Maharashtra	13.75	0.84	0.08	4.47
Orissa	22.88	0.49	0.01	1.05
Punjab	13.47	0.82	0.12	8.48
Rajasthan	21.92	0.48	0.04	2.46
Tamil Nadu	16.99	0.84	0.10	4.04
Uttar Pradesh	12.54	0.58	0.03	0.43
West Bengal	12.36	0.82	0.01	0.93

Source

NSSO. March 1997. **Consumption of some important commodities in India.** New Delhi: National Sample Survey Organization, Department of Statistics, Government of India. [Report No. 404. NSSO 50th Round 1993/94.]

Table 2.105 Monthly per capita fuel consumption in urban areas (states): 1993/94

State	*Traditional*		*Commercial*	
	Firewood and chips (kg)	*Kerosene* (litre)	*Liquefied petroleum gas* (kg)	*Electricity* (kWh)
Andhra Pradesh	7.69	1.29	0.74	8.46
Assam	11.03	1.11	1.09	2.33
Bihar	3.95	0.79	0.53	2.99
Gujarat	2.71	1.72	1.01	11.39
Haryana	5.32	1.11	1.11	12.12
Karnataka	9.51	1.79	0.68	10.54
Kerala	18.77	0.85	0.51	7.43
Madhya Pradesh	8.01	0.97	0.81	8.19
Maharashtra	2.61	2.15	1.17	15.35
Orissa	11.92	0.97	0.59	7.23
Punjab	3.21	1.54	1.31	15.35
Rajasthan	7.54	1.13	0.72	8.59
Tamil Nadu	7.96	1.82	0.65	10.08
Uttar Pradesh	6.55	0.92	0.83	5.46
West Bengal	1.95	1.38	0.74	10.19

Source

NSSO. March 1997. **Consumption of some important commodities in India.** New Delhi: National Sample Survey Organization, Department of Statistics, Government of India. [Report No. 404. NSSO 50th Round 1993/94.]

Table 2.106 Assumptions for projecting energy demand for cooking

Urban / Rural	*Coal*	*Charcoal*	*Liquefied petroleum gas*	*Superior kerosene oil*	*Natural gas*	*Electricity*	*Fuelwood*	*Agricultural waste*	*Dung*
Urban households									
Efficiency (%)	25.0	25.0	60.0	50.0	50.0	27.0	9.0	8.0	8.0
Share in 1994/95 (%)	1.8	3.4	37.4	41.5	1.7	1.1	7.7	1.8	3.6
Rural households									
Efficiency (%)	25.0	25.0	60.0	50.0	50.0	27.0	9.0	8.0	8.0
Share in 1994/95 (%)	0.5	–	–	5.7	–	–	61.7	15.5	15.4

Source

Planning Commission. 1998. **Sectoral energy demand in the Ninth Plan and the perspective period up to 2011/2012: a technical note.**

Table 2.107 Projections for energy demand for cooking and lighting

Fuel	*2001/02*	*2006/07*	*2011/12*
Liquefied petroleum gas (MT [million tonnes])	5.50	9.62	13.23
Superior kerosene oil (MT)	8.22	6.69	5.57
Coal (MT)	1.71	1.98	2.22
Charcoal (MT)	2.32	2.76	3.13
Natural gas (MCM [million cubic metres])	260	304	347
Fuel wood (MT)	174.83	174.34	171.14
Dung cake (MT)	96.80	97.44	100.04
Crop waste (MT)	59.10	63.16	67.87
Biogas (MCM)	1537	1902	2274

Source

Planning Commission. 1998. **Sectoral energy demand in the Ninth Plan and the perspective period up to 2011/2012: a technical note.** New Delhi: Planning Commission, Government of India.

Table 2.108 Projected annual consumption of different fuels by urban households of different income groups (per capita)

	All-India urban population, excluding slums (million)			*Projected annual per capita consumption in 2001*					
Annual household income (Rs)	*Distribution of households* (%)	*1991*	*2001*	*LPG*[a] (kg)	*Kerosene* (litre)	*Soft coke* (kg)	*Firewood* (kg)	*Dung cake* (kg)	*Electricity* (kWh)
Up to 500	2.5	4.1	5.8	5.0	14.7	6.4	129.2	47.0	112.4
500–1000	47.4	76.4	108.3	12.2	15.6	13.6	113.9	23.6	127.8
1000–1500	27.6	44.4	62.9	18.3	14.0	19.7	91.2	30.9	185.8
Over 1500	22.4	36.1	51.2	36.0	7.8	3.7	24.5	3.8	445.7
All categories	99.9	161.0	228.2	–	–	–	–	–	–

[a] liquefied petroleum gas

Sources

1 TERI. 1988. **Report on urban household energy policy.** Submitted to the Advisory Board on Energy, Government of India. New Delhi: Tata Energy Research Institute.

2 Sivaramakrishnan K C. 1993. **Managing urban environment in India: towards an agenda for action.** Chapter 13, Volume 3. ***Industry, Energy, Transport and Air.*** Calcutta: The Times Research Foundation.

For more details, please see TEDDY ONLINE+ [Section: Residential (fuel energy/consumption)]

Table 2.109 Annual demand for different fuels: 1989/90 to 2004/05

	1989/90	*1994/95*	*1999/2000*		*2004/05*	
Fuel	*EDSG*	*EDSG*	*EDSG*	*SEDI*	*EDSG*	*SEDI*
Commercial						
Electricity (TWh)	26.60	46.88	82.62	77.90	145.61	132.8
Liquefied petroleum gas + Superior kerosene oil (million tonnes)	9.17	12.59	17.27	18.70	23.70	25.0
Coal (for soft coke) (million tonnes)	5.00	9.00	14.00	19.80	20.00	33.2
Kerosene (million tonnes)	–	–	–	12 70	–	15.5
Liquefied petroleum gas (million tonnes)	–	–	–	6.00	–	9 5
Charcoal (million tonnes)	–	–	–	4.40	–	6.7
Non-commercial						
Fuelwood (million tonnes)	–	145.00	117.30	–	61.30	–
Agricultural waste (million tonnes)	–	44.60	36.10	–	18.90	–
Dung cakes (million tonnes)	–	79.40	64.30	–	33.60	–
Non-commercial (million tonnes of oil equivalent)	–	–	–	117.40	151.40	102.8

EDSG - Energy Demand Screening Group; SEDI - Sectoral Energy Demand for India

Sources

1 Planning Commission. 1986. **Report of the Energy Demand Screening Group.** New Delhi: Planning Commission, Government of India.

2 Planning Commission. 1991. **Sectoral Energy Demand for India.** New Delhi: Planning Commission, Government of India.

Table 2.110 Demand for heating energy and likely pattern of fuel use in rural households: 2001/02 and 2006/07

Fuel	*2001/02* *Quantity*	 *Calorific replacement* (thousand tonnes)	*2006/07* *Quantity*	 *Calorific replacement* (thousand tonnes)	*Share* (%)
Coal/soft coke (thousand tonnes)	400	600	400	600	0.25
Kerosene (thousand kilolitres)	1 863	11 551	2 290	14 198	6.06
Biogas (million cubic metres)	1 360	4 760	2 040	7 140	3.05
Dung cake (thousand tonnes)	94 858	28 457	98 709	29 613	12.64
Crop wastes (thousand tonnes)	38 959	23 765	40 882	24 938	10.65
Firewood (thousand tonnes)	17 316	132 875	210 508[a]	157 748	67.35
Total	–	202 008	–	234 237	100

[a] assuming logs form 44.3% of total firewood

Source

Natrajan I. 1997. **Biomass energy: key issues and priority needs.** Paris: Organization for Economic Cooperation and Development.

Table 2.111 Primary source of energy for lighting in rural and urban households (%): 1988/89 and 1993/94

	Rural				*Urban*			
	Kerosene		*Electricity*		*Kerosene*		*Electricity*	
State	*1988/89*	*1993/94*	*1988/89*	*1993/94*	*1988/89*	*1993/94*	*1988/89*	*1993/94*
Andhra Pradesh	59.07	50.5	38.20	49.2	25.8	17.9	72.4	81.9
Assam	84 70	84.6	9.10	14.9	29 4	25.9	67.8	73.7
Bihar	92.20	92.8	4.40	6.4	38.4	34.3	59.6	65.3
Gujarat	42.20	31.8	49.40	67.5	12.5	9.5	83.1	89.7
Haryana	41.60	23.5	57.20	74.6	7.5	9.2	91.8	89.8
Karnataka	60.10	44.9	35.80	54.5	22.5	16.6	74.8	83.2
Kerala	55.90	43.4	42.20	56.5	28.1	21.1	70.1	78.4
Madhya Pradesh	62.30	54.1	29.80	44.9	23.3	11.9	71.9	87.3
Maharashtra	50.70	41.1	45.90	58.6	15.1	9.0	83.0	90.4
Orissa	85.80	84.9	10.90	14.6	36.1	29.2	61.4	69.6
Punjab	23.80	11.0	71.40	87.3	6.1	3.0	90.8	95.9
Rajasthan	74.60	58.0	22.20	41.0	18.6	10.2	79.2	88.7
Tamil Nadu	53.20	45.7	43.20	54.0	21.5	17.6	73.9	81.7
Uttar Pradesh	89.10	81.0	9.30	17.7	30.2	25.1	66.7	74.1
West Bengal	91.10	88.2	5.80	11.2	34.4	27.9	63.1	71.4
All-India	69.20	62.4	27.04	37.1	22.6	16.5	74.4	82.8

Sources

1. National Sample Survey Organization. 1992. *Sarvekshana* XX(4): S213 and S257. New Delhi: Department of Statistics, Ministry of Planning and Programme Implementation, Government of India (50th round).
2. National Sample Survey Organization. 1997. *Sarvekshana* XX(4): 365–398. New Delhi: Department of Statistics, Ministry of Planni and Programme Implementation, Government of India (71st issue).

Table 2.112 Households (all-India) using different fuels for cooking (%): 1991

State / Union Territory	*Cow dung*	*Electricity*	*Coal/ coke/ lignite*	*Charcoal*	*Liquefied petroleum gas*	*Fuelwood*	*Biogas*	*Kerosene*
State								
Andhra Pradesh	2.76	0.12	0.14	0.86	7.75	80.85	0.48	5.95
Arunachal Pradesh	0.07	0.22	0.04	0.08	4.41	87.78	0.08	6.35
Assam	1.45	0.19	0.30	0.47	4.46	87.96	0.09	2.65
Bihar	35.44	0.23	9.93	0.91	1.97	44.03	0.15	0.60
Delhi	4.76	0.13	0.85	0.47	46.47	4.67	0.64	41.60
Goa	0.46	0.19	0.07	0.46	29.28	57.83	0.55	10.70
Gujarat	10.89	0.09	0.27	1.79	16.51	54.91	1.00	13.71
Haryana	26.36	0.14	0.44	0.82	12.91	52.10	0.35	5.82
Himachal Pradesh	0.14	0.48	0.07	0.60	6.37	82.30	0.44	9.28
Karnataka	1.16	1.86	0.04	0.08	6.35	78.58	1.17	9.78
Kerala	0.06	0.12	0.02	0.01	4.86	92.42	0.21	1.47
Madhya Pradesh	11.75	0.17	2.36	0.69	6.14	74.90	0.17	3.31
Maharashtra	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00
Manipur	0.28	0.18	0.08	0.44	6.66	85.50	0.39	3.26
Meghalaya	0.11	0.80	0.26	2.31	3.54	85.35	0.13	6.87
Mizoram	0.03	0.22	0.02	0.18	8.75	74.83	0.06	14.38
Nagaland	0.18	0.07	0.06	0.03	2.67	93.11	0.08	3.16
Orissa	13.50	0.68	2.41	0.57	2.27	73.47	0.26	1 77
Punjab	35.28	1.53	0.35	0.26	14.14	35.91	1.00	10.35
Rajasthan	7.61	0.06	0.25	1.14	6.23	78.09	0.17	5.62
Sikkim	0.02	0.40	0.34	0.26	2.63	74.47	0.23	21.24
Tamil Nadu	1.25	0.13	0.02	0.04	7.29	80.35	0.79	9.63
Tripura	0.46	0.07	0.02	1.54	3.35	91.52	0.09	1.92
Uttar Pradesh	0.49	1.62	0.04	0.13	8.08	77.87	0.15	9.80
West Bengal	18.04	0.21	23.57	2.12	4.87	32.13	0.22	3.69
Union Territory								
Andaman and Nicobar Islands	0.06	0.07	0.06	0.01	3.97	71 47	0.51	22.66
Chandigarh	1.24	0.15	0.45	0.04	49.03	7.23	0.13	40 64
Dadra and Nagar Haveli	0.14	0.05	0.02	0.06	8.81	79.12	0 58	11 06
Daman and Diu	5.73	0.09	0.04	0.03	29.40	49.84	0 63	13.90
Lakshadweep	0.00	0.07	0.00	0.00	1.03	90 69	0.00	3 56
Pondicherry	1.48	0.08	0.05	0.04	15.26	61.24	0.83	18.44
All-India[a]	15.39	0.31	3 47	0.77	7.94	61.50	0.49	7.16

[a] excluding Jammu and Kashmir

Source

GoI. 1995. **Housing and amenities**. Occasional Paper No. 5 of 1994. ***Census of India 1991***. New Delhi: Office of the Registrar General and Census Commissioner, Government of India.

Table 2.113 Distribution of rural households by primary source of energy (traditional) for cooking (states) (%): 1989/90 to 1993/94

	1989/90		*1991*		*1993/94*	
State	*Firewood and chips*	*Gobar gas/ dung cake/ charcoal*	*Fuelwood*	*Cow dung*	*Firewood and chips*	*Gobar gas/ dung cake / charcoal*
Andhra Pradesh	90.9	1.6	91.60	3.37	93.7	3.3
Assam	98.9	0	93.10	1.60	97.2	1.7
Bihar	66.4	27.0	47.40	39.50	63.4	25.9
Gujarat	84.8	6.4	75.90	14.35	78.7	12.9
Haryana	54.3	43.3	63.00	31.78	68.3	28.4
Karnataka	94.6	0.7	94.40	1.44	93.9	2.6
Kerala	94.4	0.1	96.80	0.06	92.1	4.6
Madhya Pradesh	90.1	6.8	82.90	14.56	91.1	6.9
Maharashtra	80.2	5.4	72.70	14.34	76.7	6.1
Orissa	87.4	9.1	77.10	15.21	88.9	4.5
Punjab	39.1	48.3	0.40	1.80	50.7	39.3
Rajasthan	93.6	4.2	88.00	9.07	90.0	6.5
Tamil Nadu	95.1	0.6	94.10	1.53	91.3	3.5
Uttar Pradesh	58.7	38.1	84.20	0.49	62.7	34.2
West Bengal	71.4	7.0	41.50	24.48	61.3	9.2
All-India	78.9	0.3	71.69	19.60	78 2	13.7

Sources

1 National Sample Survey Organization. 1997. **Energy used by Indian households.** New Delhi: Department of Statistics, Government of India. [Report No. 410/2.]

2 National Sample Survey Organization. 1992. *Sarvekshana* XVI-1. New Delhi: Department of Statistics, Government of India (July-September) (52).

3 GoI. 1995. **Housing and amenities.** Occasional Paper No. 5 of 1994. ***Census of India 1991.*** New Delhi: India, Office of the Registrar General and Census Commissioner, Government of India.

Table 2.114 Distribution of rural households by primary source of energy (commercial) for cooking (states) (%): 1989/90 to 1993/94

	1989/90			*1991*			*1993/94*		
State	*Gas (coal, oil or LPG)*	*Kerosene*	*Coke and coal*	*LPG*	*Kerosene*	*Coal/ coke/ lignite*	*Gas (coal, oil or LPG)*	*Kerosene*	*Coke and coal*
Andhra Pradesh	1.4	1.1	0.4	2.07	0.87	0.60	2.3	1.3	0.4
Assam	0.5	0.2	0.3	1.32	0.65	0.23	1.1	0.3	0.4
Bihar	0.2	0.2	3.8	0.18	0.14	4.52	0.3	0.2	4.1
Gujarat	1.8	4.7	0.8	3.38	3.77	0.11	4.9	6.9	0.7
Haryana	0.4	0.9	0.4	1.85	1.28	0.15	3.6	1.8	0.1
Karnataka	0.8	1.6	0.4	0.73	1.23	0.02	1.7	1.9	0.2
Kerala	1.7	1.6	0.6	1.56	0.57	0.01	4.1	1.3	0.6
Madhya Pradesh	0.5	0.7	1.5	0.47	0.51	0.60	0.5	0.3	1.4
Maharashtra	2.2	4.6	0.4	2.87	4.70	0.21	3.5	5.1	0.3
Orissa	0.1	0.3	0.4	0.42	0.29	0.64	0.3	0.4	0.5
Punjab	2.7	5.8	0.6	44.99	2.70	0.11	5.1	8.3	0.2
Rajasthan	0.1	1.5	0.4	0.51	0.97	0.07	2.0	1.4	0.7
Tamil Nadu	1.0	1.8	0.3	1.36	1.76	0.01	3.1	3.8	0.1
Uttar Pradesh	0.3	0.6	1.3	4.48	7.22	0.03	1.2	1.0	0.4
West Bengal	0.1	0.3	11.8	0.57	0.32	10 94	0.3	0.9	6.5
All-India	0.8	1.5	1.9	1.22	1.34	1.54	1.9	2.0	1.4

LPG - liquefied petroleum gas

Sources

1 National Sample Survey Organization. 1997. **Energy used by Indian households.** New Delhi: Department of Statistics, Government of India. [Report No. 410/2.]

2 National Sample Survey Organization. 1992. *Sarvekshana* XVI-1. New Delhi: Department of Statistics, Government of India (July-September) (52).

3 GoI. 1995. **Housing and amenities** Occasional Paper No. 5 of 1994. ***Census of India 1991***. New Delhi: India, Office of the Registrar General and Census Commissioner, Government of India.

Table 2.115 Distribution of urban households by primary source of energy (traditional) for cooking (states) (%): 1989/90 to 1993/94

	1989/90		*1991*		*1993/94*	
State	*Firewood and chips*	*Gobar gas/ dung cake/ charcoal*	*Fuelwood*	*Cow dung*	*Firewood and chips*	*Gobar gas/ dung cake / charcoal*
Andhra Pradesh	51.9	0.9	47.99	0.86	44.1	0.6
Assam	56.6	0.2	52.10	0.39	44.1	0.4
Bihar	26.3	7.1	21.91	8.75	21.8	5.3
Gujarat	24.7	2.7	17.15	4.67	16.1	3.3
Haryana	29.3	14.5	23.42	12.13	23.8	9.5
Karnataka	55.3	0.4	43.36	0.54	36.2	0.3
Kerala	65.4	0.2	79.47	0.07	70.1	0.1
Madhya Pradesh	47.1	2.3	48.29	2.42	41.4	2.2
Maharashtra	22.6	0.6	13.66	2.35	13.8	0.7
Orissa	59.3	1.8	50.28	2 70	42.3	4.3
Punjab	18.0	13.6	15.00	9.96	14.5	6.5
Rajasthan	53.9	2.2	45.34	2.78	39.0	4.7
Tamil Nadu	50.8	0.9	50.79	0.64	42.9	0.5
Uttar Pradesh	43.5	10.1	12.86	0.48	39.1	8.4
West Bengal	11.2	1.8	9.00	2.18	8.4	0.8
All-India	37.4	3.5	32.74	3.51	29.9	2.7

Sources

1 National Sample Survey Organization. 1997. **Energy used by Indian households.** New Delhi: Department of Statistics, Government of India. [Report No. 410/2.]

2 National Sample Survey Organization. 1992. *Sarvekshana* XVI-1. New Delhi: Department of Statistics, Government of India (July-September) (52).

3 GoI. 1995. **Housing and amenities.** Occasional Paper No. 5 of 1994. ***Census of India 1991.*** New Delhi: India, Office of the Registrar General and Census Commissioner, Government of India.

Table 2.116 Distribution of urban households by primary source of energy (commercial) for cooking (states) (%): 1989/90 to 1993/94

	1989/90			*1991*			*1993/94*		
State	*Gas (coal, oil or LPG)*	*Kerosene*	*Coke and coal*	*LPG*	*Kerosene*	*Coal/ coke/ lignite*	*Gas (coal, oil or LPG)*	*Kerosene*	*Coke and coal*
Andhra Pradesh	19.4	19.7	0.9	25.19	21.53	0.36	27.9	0.2	2.4
Assam	16.6	12.8	4.7	26.65	16.71	0.77	34.5	15.5	0.7
Bihar	11.2	0.6	45.7	13.77	3.63	45.63	17.2	8.9	39.1
Gujarat	38.0	27.2	5.4	40.03	31.53	0.56	39.6	31.0	2.2
Haryana	29.5	20.6	4.6	41.95	17.77	1.20	38.6	23.0	0.7
Karnataka	14.0	19.0	1.2	18.84	28.78	0.90	26.0	26.5	0.5
Kerala	17.9	7.1	1.9	14.67	4.16	0.04	16.8	5.2	0.2
Madhya Pradesh	25.3	9.3	12.8	24.95	12.58	8.19	30 8	15.6	5.9
Maharashtra	33.9	32.5	2.9	36.99	43.99	1.27	38.8	37.6	0.5
Orissa	0.9	7.9	12.2	13.98	11.13	13.65	18.0	12.0	7.6
Punjab	27.8	34.3	2.4	41.10	27.96	1.03	40.9	35.9	0.9
Rajasthan	18.4	19.4	5.1	25.15	20.97	0.84	28.4	24.2	0.7
Tamil Nadu	18.1	23.2	0.4	20.04	26.59	0.04	19.2	25.0	0.3
Uttar Pradesh	18.5	12.4	9.1	45.19	36.42	0.12	31.5	14.8	2.8
West Bengal	11.5	0.8	51.0	15.44	11.99	54.65	18.7	14.0	29.9
All-India	22.3	19.2	10.7	26.93	23.62	8.95	29.6	23.2	5.7

LPG – liquefied petroleum gas

Sources

1 National Sample Survey Organization. 1997. **Energy used by Indian households**. New Delhi: Department of Statistics, Government of India. [Report No. 410/2.]

2 National Sample Survey Organization. 1992. *Sarvekshana* XVI-1. New Delhi: Department of Statistics, Government of India (July–September) (52).

3 GoI. 1995. **Housing and amenities**. Occasional Paper No. 5 of 1994. ***Census of India 1991***. New Delhi: India, Office of the Registrar General and Census Commissioner, Government of India.

FORESTS

Forests

At a glance

- India supports approximately 16% of the world's human and 18% of livestock population on merely 2.5% of the world's geographical area, including 1.8% of forest area.
- The recorded forest area is 76.52 Mha (million hectare) or 23.28% of the country's total geographical area of 328.73 Mha, most of which (over 90%) is owned and managed by the state.
- The forest area comprises 37.74 Mha of dense forest (crown density >40%), 25.51 Mha of open forest (crown density 10%–40%) and 0.487 Mha of mangroves and another 5.19 Mha of scrub cover.
- Forests meet nearly 40% of the energy needs of the country (mainly in rural areas) and about 30% for the fodder needs of the livestock population.
- The per capita availability of forest land in India is one of the lowest in the world – 0.08 ha against an average of 0.5 ha for developing countries and 0.64 ha for the world (MoEF 1999).
- The biomass and growing stocks in the natural forests of India is 93 T/ha and 47 m^3/ha, respectively, as against an average of 169 T/ha and 11.3 m^3/ha for developing countries, indicating that availability of forest biomass per capita (from natural forests) is only about 6 T as against an average of 82 T in the developing world.
- The main causes of deforestation and forest degradation in India include unsustainable use and inappropriate management of the resource resulting in loss of vegetation through land clearances for agriculture (including shifting cultivation), over-cutting beyond silviculturally permissible limits, unsustainable fuelwood and fodder extraction, encroachment into forest land, diversion of forest land for non-forestry purposes, forest fire and over-grazing.

Introduction

A forest comprises an ecological system consisting of tree-dominated vegetative associations, which not only provides timber, fuel and pulp wood, fodder and fibre, and NWFPs (non-wood forest products), but also maintain the ecological balance and life-support systems essential for life on earth. The key element of this terrestrial ecological system, forests with their innate complexity and inherent diversity, are a complete renewable resource base as well as a habitat for a myriad of life forms, with numerous goods and services. Some of the major economic and environmental services which forests provide are listed below (TERI 1998).

- Services of consumptive direct-use value such as timber, fuelwood, fodder and fibre, and a wide range of non-wood products

- Services of optional value such as a natural habitat for biodiversity and a repository of genetic wealth
- Services of non-consumptive direct-use value like recreation and ecotourism
- Services of local indirect-use value that are an integral part of the watershed, which regulate water regimes, conserve soil, and control flooding
- Services of global indirect-use value like carbon sequestration and carbon sink.

India's forest profile

According to FSI (Forest Survey of India) (2000), the recorded forest area is 76.52 Mha (million hectare) or 23.28% of the country's total geographical area of 328.73 Mha, most of which (over 90%) is under public/government ownership and managed by the state forest departments. Some areas such as the Civil Soyam Forests of Uttar Pradesh and customarily-owned forest lands of the north-eastern states are outside the control of the state forest departments.

The actual forest cover, according to FSI (2000), is 63.73 Mha (19.39%) although the National Forest Policy 1952 and 1988 stipulates that at least one-third of the land area of the country should be under forest or tree cover. This consists of 37.74 Mha of dense forest (crown density >40%), 25.51 Mha of open forest (crown density 10%–40%) and 0.487 Mha of mangroves, constituting 11.48%, 7.76%, and 0.15% of the geographic area, respectively. In addition, there is another 5.19 Mha (1.58%) of scrub cover (Map 1).

In terms of types of forest, about 41.65 Mha are reserved forests, 22.33 Mha protected forests, and the remaining 12.54 Mha unclassed forests, constituting 54.44%, 29.18%, and 16.38% of the forest area, respectively.

On functional basis, approximately 10 Mha are under protection forests; 15 Mha production forests, 25 Mha social forests, and 15.3 Mha protected area network.

It is estimated that about 66% of the forests occur below an elevation of 600 m, 25% between 600 and 1800 m, and the rest above 1800 m. The occurrence of forests is negligible above the tree line.

Wide disparity exists in the extent of forest cover across the country. Forests in the Andaman and Nicobar Islands occupy as much as 86.9% of the total geographical area, whereas forests in Haryana occupy only 3.8%. Arunachal Pradesh, Himachal Pradesh, Manipur, Mizoram, Nagaland, and Tripura have over 50% of their land areas under forests, while Gujarat, Jammu and Kashmir, Punjab, and Rajasthan have less than 10%. The forest area in other states ranges between 10% and 50% of their land areas.

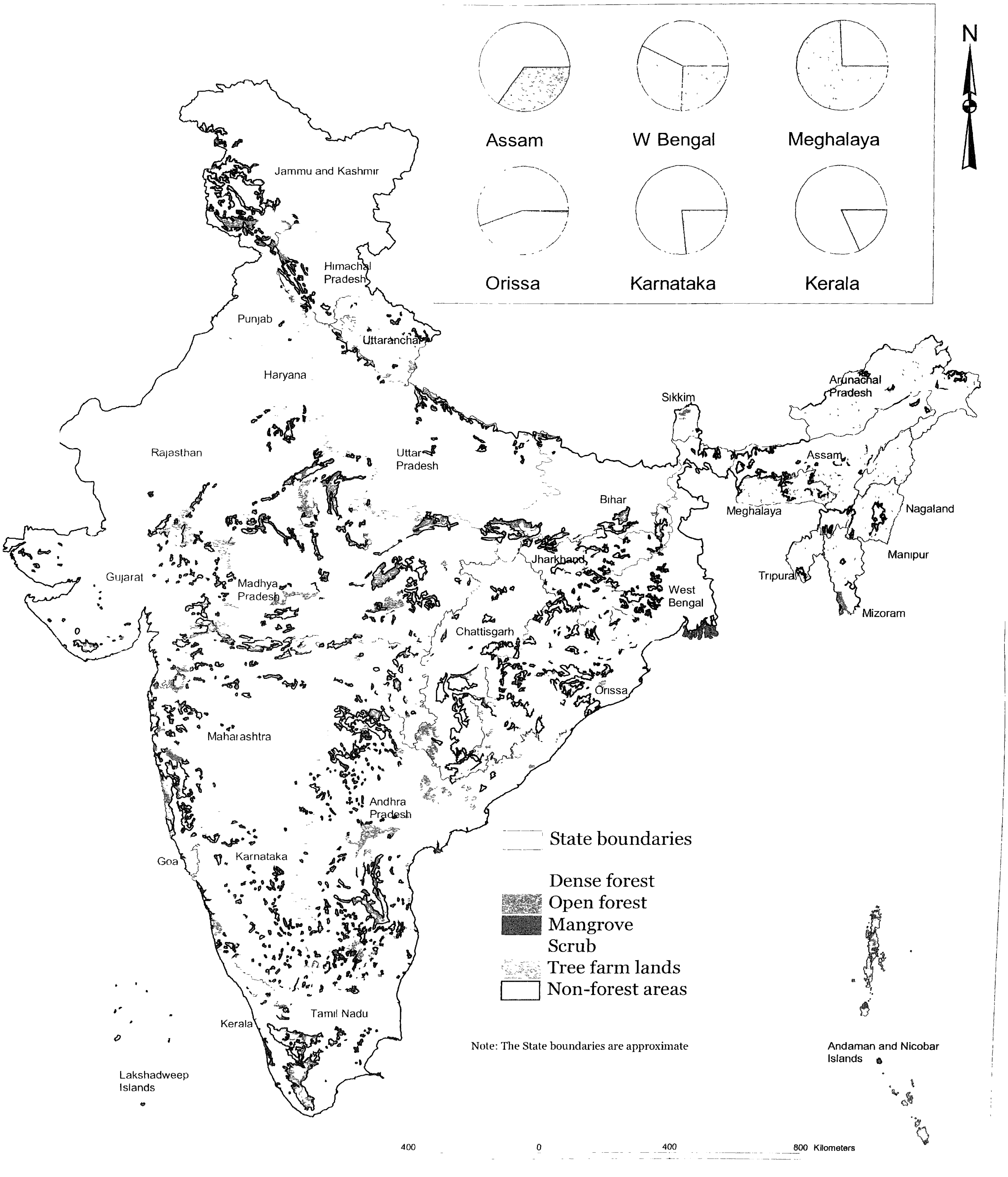
India is one of the 12 mega diversity countries with a wide variety of flora and fauna, commanding over 8% of world's biodiversity. It supports 16 major forest types, ranging from tropical rain forests to dry thorn forests and mountain temperate forests. The tropical deciduous types (both moist and dry) constitute the bulk (over 65%) of the forests. The diversity in forest types warrants diverse management, research, development, and policy interventions.

Current status

India supports approximately 16% of the world's human and 18% of livestock population on merely 2.5% of the world's geographical area, including 1.8% of forest area. Forests meet nearly 40% of the energy needs of the country of which more than 80% is utilized in rural India, and about 30% for the fodder needs of the livestock population. An estimated 270 million tonnes of fuelwood, 280 million tonnes of fodder, over 12 million tonnes of timber and innumerable NWFPs are removed from forests annually (MoEF 1999).

The *State of Forests Report 1997* (FSI 1998) estimates that the growing stock of the country (including natural forest, forest plantations and areas other than natural forests) is 4740.8 MCM (million cubic metres) with an annual increment of 87.62 MCM. Of this, about 60% (52.62 MCM) is estimated to be timber and 40% (35 MCM) fuelwood. This represents an average volume of 74.42 m^3/ha, with an incremental annual growth of 1.36 m^3/ha/year, which compares poorly with the global average of 120 m^3/ha and the average annual growth of 2.1 m^3/ha. It is clear that the forest resource of the country is not being managed to its full potential. Some of the reasons for this are that sustainable forest management is complex, costly, and difficult; research and technology inputs have been low and sporadic; and updated management information lacking.

Forests contribute 1.7% to the GDP (gross domestic product) of the country. However, this figure does not take into account its numerous



Map 1. National vegetation map of India

Source:
Forest Survey of India, Ministry of Environment and Forests, Government of India

non-market and external benefits and the vast amount of fuelwood and fodder collected or the fuelwood and timber harvested illegally. The collection of NWFPs by villagers is also not recorded fully.

Direct benefits derived

Fuelwood

India is the world's largest consumer of fuelwood, and about 70% of the wood produced from forests is used as fuelwood. Fuelwood consumption, which grew at a rate of about 2.4% per annum between 1980 and 1994 (MoEF 1999), was estimated at 260 million cubic metre in 1997 against a sustainable supply of only 52.6 million cubic metres, less than 20% of the total demand (TERI 1998).

Timber

The total demand for timber, including small timber, was estimated at 64.4 MCM with a growth rate of five per cent per annum (FSI 1996a). However, only 40% of the commercial demand for timber is met from the sustainable supply from forests.

Non-wood forest products

Nearly 500 million people living in and around forests in India depend on NWFPs for a critical component for their sustenance. Moreover, several NWFPs are not only exported but also sustain a large number of rural, cottage, and other industries. The NWFPs provide about 40% of the total official forest revenues and 55% of forest-based employment. The total value of NWFPs exported during 1990/91 was over 16.785 billion rupees.

Habitat for flora and fauna

India contributes over eight per cent to the total known global biological diversity with a species count of 0.126 million, and has 2 of the 18 identified 'hot spots' (Western Ghats and Eastern Himalayas) of the world. India's forests support a wide variety of flora and fauna. More than 5150 species of plants, 16 214 species of insects, 44 mammals, 42 birds, 164 reptiles, 121 amphibians and 435 species of fish are endemic in the ecosystem of the country. In order to provide *in situ* conservation, a wide protected area network, comprising 88 national parks, and 490 wildlife sanctuaries have b
forests, represent
graphical area of

Safeguard

The role of fores
ment through car
and reducing em
gases) is well reco
tential for reducin
with forests and
rectly, forests a
warming and oz
data about carbo
ment per unit of a
use are yet to b
floods, landslides
denudation of hill
the ecologically fr

Concerns

Exorbitant increa
population during
erty has exerted tr
est resource of
deforestation and
the poor databas
rates, it has been
nual rate of defore
in the 1970s to 0.
about 0.129 durin
availability of fore
lowest in the worl
of 0.5 ha for develo
the world (MoEF

The deterioratio
productivity of for
cern today. Most o
are ecologically in
resulting in a loss
genetic wealth an
growing stocks in t
93 T/ha and 47 m^3
average of 169 T/h
oping countries, in
forest biomass per
of India is only abo
82 T in the develo

Deforestation ar
are affecting

1 the environmen
stability, damag

of agriculture, loss of biodiversity, reduction in carbon sink capability, effect on climate, increased incidence of floods and droughts, damages to watersheds, silting of reservoirs, soil erosion, desertification, and changes in hydrological regime;

2 the economy through fall in agricultural productivity and crop yields, scarcity of forest products, closure/unused capacity of forest industries and continued and cumulative disinvestment of forest capital; and

3 the society through loss of employment and threat to food, health, and livelihood security.

There has been considerable depletion of the forest resources during the recent past due to deforestation and forest degradation caused by human interference, creating various pressures. Although it is difficult to separate the causes and effects of deforestation and forest degradation, they mainly stem from unsustainable use and inappropriate management of the resource resulting in loss of vegetation through land clearances for agriculture (including shifting cultivation), over-cutting beyond silviculturally permissible limits, unsustainable fuelwood and fodder extraction, encroachment into forest land, diversion of forest land for non-forestry purposes, forest fire, and over-grazing. The pressure on forest resources has additionally led to over-exploitation of marginal resources, mainly from forests and common lands, which has seriously affected the lives of a large section of Indian population, particularly the poor, who live close to forests. Some of the factors contributing to the causes and effects of deforestation and forest degradation are briefly described below.

Shifting cultivation

A report by the World Bank (1993) indicates that about 10 Mha of forest area is under shifting cultivation, although there are varying estimates given by different agencies. Shifting cultivation is practised in about 16 states, but mostly in the tribal dominant areas of the north-eastern states where it accounts for most of the forest degradation. Tribal population increased from 5.7% in 1971 to 8% in 1991. The increase in the population of shifting cultivators and the declining productivity of forest soils have shortened the shifting cultivation cycle from about 20 years to 4 years. Such intense farming on poor quality forest soils has made the system ecologically fragile (MoEF 1999).

Excessive wood extraction

Extraction of wood from forests for fuel is one of the most important causal factors of forest degradation in India. Fuelwood consumption was estimated at 260 MCM in 1997 as against the sustainable supply of 52.6 MCM (TERI 1998). This is considerably (4 to 5 times) higher than what can sustainably be removed from the forests. It is estimated that fuelwood consumption has grown at a rate of about 2.4% per annum between 1980 and 1994 (MoEF 1999).

In 1990, estimated excess (mostly unrecorded) removal of fuelwood was about 250 MCM with an expected increase to 310 MCM by 2000 (MoEF 1999). Even though some fuelwood may come from household plots and non-forest sources, a substantial quantity of fuelwood is obtained by unrecorded over-cuts. The total demand for timber, including small timber, was estimated at 64.4 MCM for 1996 with a growth rate of 5% per annum (FSI 1996b) whereas the sustainable yield from India's forests was estimated at 26 MCM for 1997 and 29 million for 2000 (Chemprojects Design and Engineering Pvt. Ltd 1999). As such, less than half of the commercial demand for timber and less than 20% of the demand for fuelwood are being met by the sustainable supply. The difference between the demand and the supply is obviously met through unrecorded extractions, thereby steadily increasing the rate of forest degradation and deforestation.

In 1991, the production from Indian forests was estimated at 15 227 million dollars and consumption at 15 587 million dollars, outstripping production by a gap of 360 million dollars (FAO 1993). Sustainable yield from forests has also been falling with degradation of forests and has resulted in a fall in industrial and fuelwood production. Further, it was estimated that the annual loss of industrial wood in 1997 in terms of pricing was 45 billion rupees and that of fuelwood 12 billion rupees (Ganguly 2000).

Grazing pressure

In the absence of adequate productive pasture lands and of a grazing policy, forests have become the major source of grazing and fodder. It is estimated that around 60% of the livestock (about 270 million) graze in forests. These

lude traditional sedentary village livestock and
gratory animals herded by ethnic graziers. Ad-
ionally, graziers collect about 175 million
ines of green fodder annually, by lopping and
rvesting grasses. Overgrazing and over-extrac-
n of green fodder lead to forest degradation
ough disturbance in vegetative regeneration,
mpaction of soil and increased potentiality of
il erosion. A sample survey by the FSI estimates
at in about 53% of natural forests, natural re-
neration is either absent or inadequate, mainly
e to overgrazing far exceeding its carrying ca-
city, and that the impact of grazing affects ap-
oximately 78% of the country's forests. Grazing
curs even in protected areas and 67% of the na-
nal parks and 83% of the wildlife sanctuaries
re found to have grazing incidents.

Forest fire

rest fires, mostly ground fires, which annually
ect about 35 Mha of forest area, are, by and
ge, incendiary in nature. About 90% of the for-
fires are caused by human agencies to promote
new flush of grasses, collection of fruits and
ney, or to prepare land for shifting cultivation.
sample survey conducted by the FSI in 1995
und that the fires affect around 55% of the for-
t area annually. Such fires have wide-ranging
pacts, the nature and severity of which depend
the type of forest, availability of fuel, and cli-
atic factors.

Diversion of forest land

ansfer of forest lands for other land uses, en-
oachment on forest lands (at present about 1.5
ha) for agriculture or other purposes, and inci-
nce of pests and diseases are contributing to
forestation and/or forest degradation signifi-
ntly. However, the implementation of the For-
t (Conservation) Act, 1980 has reduced the
erage rate of diversion from 150 000 ha/year be-
een 1950 and 1980 to 25 000 ha/year, and fur-
er to 15 500 ha/year during the last five years.

Initiative to improve the forestry sector

alizing the need for a long-term forestry action
ogramme to manage forest resources on a sus-
inable basis and to increase the forest cover and
oductivity in the country, India has come up
ith the *National Forestry Action Programme – In-*
a in 1999 under a project of the United Nations Development Programme and the Food and Agriculture Organization. Integrating the 26 State Forestry Action Programmes shows vast variations in socio-economic and ecological conditions. The objective is to develop a comprehensive strategy and action plan of 20 years for sustainable development of forests in conformity with the provisions of the National Forest Policy, 1988 and address the major issues of the forestry sector. The broad thrust areas of the programme are as follows.

- *Protect existing forest resources* It has three main sub-programmes: (1) forest protection, (2) soil and water conservation, and (3) protected areas and biodiversity conservation. These include the works of forest survey, demarcation and mapping, inventory, biodiversity conservation, protected area management, protection against poaching, encroachment, fire, and other related issues.
- *Improve forest productivity* It has four main sub-programmes: (1) rehabilitation of degraded forests, (2) research and technology development, (3) development of NWFPs, and (4) assisting private initiatives with community participation. These involve mainly research, improvement in technology, enrichment planting, soil and water conservation, regeneration, rehabilitation, and afforestation mainly in existing forests.
- *Reduce total demand* It has three main sub-programmes for efficient uses of (1) fuelwood and fodder, (2) timber, and (3) NWFPs. This includes the programmes for reduction of demand placed on forests through the technology of preservation, seasoning, substitutions, and other measures for efficient utilization of forest products and also through extensive biomass plantation.
- *Strengthen policy and institutional framework* It has three main sub-programmes for strengthening (1) central forestry administration, (2) central forestry institutions, and (3) state forestry administration and institutions. These include the development of infrastructures like buildings, communications, etc. and strengthening staff, including HRD (human resource development). This issue also covers all aspects of capacity building, forest policy and legislation, public forest administration and organizational structure, research, planning, budgeting, etc.

- *Expand forest area* It has two main sub-programmes: (1) tree plantation on forest and non-forest lands and (2) people's participation in plantations and its protection. This issue includes the extension of forestry programmes to all kinds of wasteland and marginal farmland. It also includes programmes to create plantation forestry through wasteland reclamation, afforestation, and the promotion of agroforestry.

Broad plan outline to improve the forestry sector

- For the sustainability of forests, productivity of forest plantations to be increased at least 3–5 m^3/ha/year by promoting regeneration and enrichment plantations.
- Hygiene of forests to be improved through suitable silvicultural practices.
- Efforts to be made to bring one-third of the land area of the country under forest and tree cover by plantations on all categories of wastelands and agroforestry.
- Protected area network to be expanded and managed for biodiversity conservation.
- Plantations on non-forest wastelands to be done mostly with fuelwood species as 70% of the wood produced from forests are used as fuelwood. Species of pulpwood and other industrial wood may be encouraged in farm forestry.
- Institution for people's participation in the protection and development of degraded and fringe forests to be strengthened.
- NWFP species to be developed and value addition may be promoted at the village level.
- Grazing in forests to be regulated as per carrying capacity and silvicultural needs.
- Infrastructure for forest inventory, research and development to be strengthened. HRD should also be improved.
- Investment for sustainable development of forests should be rational and proportionate to the total production.

References

Chemprojects Design and Engineering Pvt. Ltd. 1999
Study on forest industry
Report submitted to the Ministry of Environment and Forests, Government of India, New Delhi
New Delhi: Chemprojects Design and Engineering Pvt. Ltd.

FAO (Food and Agriculture Organization). 1993
Forestry Statistics: Today for Tomorrow
Rome: FAO

FSI (Forest Survey of India). 1996a
Fuelwood, timber, and fodder from forests of India
Dehra Dun: FSI. 35 pp.

FSI (Forest Survey of India). 1996b
State of Forests Report 1995
Dehra Dun: F+
SI. 98 pp.

FSI (Forest Survey of India). 1998
State of Forests Report 1997
Dehra Dun: FSI. 72 pp.

FSI (Forest Survey of India). 2000
State of Forests Report 1999
Dehra Dun: FSI. 113 pp

Ganguli B N. 2000
Forest management options beyond 2000: issues and opportunities for India.
Paper presented at *India's Forests Beyond 2000.* Organized by the Commonwealth Forestry Association, India and the Indian Council of Forestry Research and Education, 19–20 April 2000.

MoEF (Ministry of Environment and Forests). 1999
National Forestry Action Programme – India (Vol. 1)
New Delhi: MoEF, Government of India. 179 pp.

MoEF (Ministry of Environment and Forests). 2001
Annual Report 2000/2001
New Delhi: MoEF, Government of India. 212 pp.

TERI. 1998
Forest resources
In *Looking Back to Think Ahead,* edited by R K Pachauri and P V Sridharan.
New Delhi: Tata Energy Research Institute. 346 pp.

The World Bank. 1993
Policies and issues in forest sector development
New Delhi: The World Bank

Table 3.01 Contribution (**million rupees**) of forestry and logging to the GDP (gross domestic product) and its share (%): 1980/81 to 1998/99

Year	*Contribution to GDP by logging in total GDP (%)*		*All-India GDP*		*Share of forestry and forestry and logging*	
	Current prices	*Constant (1980/81) prices*	*Current prices*	*Constant (1980/81) prices*	*Current prices*	*Constant (1980/81) prices*
1980/81	32 620	32 620	1 224 270	1 224 270	2.66	2.66
1984/85	50 530	31 800	2 085 330	1 504 330	2.42	2.11
1988/89	68 280	29 400	3 527 060	1 884 610	1.94	1.56
1992/93	86 690	30 950	6 276 340	2 234 380	1.38	1.39
1993/94[a]	114 540	114 540	7 813 450	7 813 450	1.50	1.50
1994/95	129 780	117 670	9 141 940	8 358 640	1.40	1.40
1995/96	133 900	117 010	10 672 200	8 969 900	1.30	1.30
1996/97	144 930	118 650	12 372 900	9 643 900	1.20	1.20
1997/98	151 370	120 770	13 844 460	10 128 160	1.10	1.20
1998/99	184 370	124 020	16 123 830	10 818 340	1.10	1.10

[a] from 1993/94 onwards the estimates are 1993/94 prices

Sources

1 CSO. 1996. ***National Accounts Statistics***. pp. 168-169. New Delhi: Central Statistical Organization 247 pp.

2 CSO. 1997. **CSO's press note on quick estimates of national income consumption, expenditure, saving and capital formation, 1996/97.** New Delhi: Central Statistical Organization (For 1995/96 and 1996/97.)

3 CSO. 2000. ***National Accounts Statistics***. pp. 16-17. New Delhi: Central Statistical Organization. 218 pp.

For more details, please see TEDDY ONLINE+ [Section: Forest (macro and state level data)]

Table 3.02 Extent of dense forest, open forest, and mangroves (km^2): 1999 assessment

State / Union Territory	*Dense forest*	*Open forest*	*Mangroves*	*Scrub*
State				
Andhra Pradesh	24 190	19 642	397	9 559
Arunachal Pradesh	57 756	11 091	–	104
Assam	14 517	9 171	–	324
Bihar	13 274	13 200	–	1 914
Delhi	35	53	–	3
Goa	995	251	5	16
Gujarat	6 430	5 504	1031	2 948
Haryana	449	515	–	191
Himachal Pradesh	9 120	3 962	–	566
Jammu and Kashmir	11 019	9 422	–	3 089
Karnataka	24 832	7 632	3	4 489
Kerala	8 429	1 894	–	91
Madhya Pradesh	81 619	50 211	–	3 853
Maharashtra	26 613	19 951	108	7 160
Manipur	5 936	11 448	–	177
Meghalaya	5 925	9 708	–	261
Mizoram	3 786	14 552	–	125
Nagaland	5 137	9 027	–	14
Orissa	26 073	20 745	215	5 439
Punjab	517	895	–	107
Rajasthan	4 309	9 562	–	6 921
Sikkim	2 363	755	–	386
Tamil Nadu	8 659	8 398	21	2 836
Tripura	2 228	3 517	–	38
Uttar Pradesh	22 902	11 114	–	1 177
West Bengal	3 565	2 672	2125	98
Union Territory				
Andaman and Nicobar Islands	6515	125	966	–
Chandigarh	6	1	–	–
Dadra and Nagar Haveli	159	43	–	10
Daman and Diu	–	3	–	–
Lakshadweep[a]	–	–	–	–
Pondicherry[a]	–	–	–	–
Total	377 358	255 064	4871	51 896

[a] no discernible forest cover

Sources

1 FSI. 1993. *The State of Forests Report, 1992*. p. 25. Dehra Dun: Forest Survey of India.
2 FSI. 1995. *The State of Forests Report, 1994*. p. 24. Dehra Dun: Forest Survey of India. 98 pp.
3 FSI. 1997. *The State of Forests Report, 1996*. pp. 6–7. Dehra Dun: Forest Survey of India. 72 pp.
4 FSI. 2000. *The State of Forests Report, 1999*. p. 10. Dehra Dun: Forest Survey of India.

For more details, please see TEDDY ONLINE+ [Section: Forest (forest cover)]

Table 3.03 Productivity of forests (m^3/ha)

State / Union Territory / Project	*Range*	*Average*
State		
Andhra Pradesh	22.7-80.2	60.9
Arunachal Pradesh	109-221	147.3
Assam	44.9-148.1	116.6
Bihar	16.70-61.46	37.5
Goa, Daman, and Diu	–	116.4
Gujarat	–	59.3
Haryana	–	13.9
Punjab	–	13.9
Himachal Pradesh	75.9-277.2	161.8
Jammu and Kashmir	130.9-276.4	226.2
Karnataka	7.3-79.4	56.4
Madhya Pradesh	32.4-82.9	63.9
Maharashtra	15-154	67.7
Meghalaya	80.2-100.7	–
Manipur	45.8-61.7	–
Mizoram	25.0-52.4	30.8
Nagaland	53.8-104.1	56.9
Orissa	37-61	57.0
Rajasthan	10.1-26.0	13.8
Sikkim	74.0-218.4	116.4
Tripura	–	23.1
Uttar Pradesh	14.4-185.4	109.6
West Bengal	5.0-225.3	32.0
Union Territory		
Andaman and Nicobar Islands	75.0-268.3	157.1
Dadra and Nagar Haveli	–	53.0
Food and Agriculture Organization projects		
Yamuna catchment	–	201.0
Madhya Pradesh, Andhra Pradesh, and Orissa	–	61.6
Kerala and Tamil Nadu	–	87.8
All India	–	77.3

Sources

1 FSI. 1993. ***The State of Forests Report, 1992***. Dehra Dun: Forest Survey of India.

2 FSI. 1995. ***The State of Forests Report, 1994***. Dehra Dun: Forest Survey of India. 98 pp.

3 FSI. 1997. ***The State of Forests Report, 1996***. Dehra Dun: Forest Survey of India. 72 pp.

Table 3.04 Statewise annual fuelwood availability and biofuel consumption (air dry million tonnes)

State / Union Territory	*Fuelwood availability* (thousand m^3)	*Fuelwood*			*Dungcake*			*Agricultural residue*		
		REDB	*IREP*	*NCAER*	*REDB*	*IREP*	*NCAER*	*REDB*	*IREP*	*NCAER*
State										
Andhra Pradesh	1 779	23.2	10.8	9.74	9.5	2.9	2.26	18.6	3.6	1.75
Arunachal Pradesh	4 573	0.5	0.5	0.09	0.1	0	0	0.1	0	0.06
Assam	1 818	13.7	12.3	2.26	1.4	0	0	2.7	0	1.46
Bihar	514	34.1	26.9	8.90	8.2	9.9	19.89	7.8	13.0	5.99
Goa, Daman, and Diu	70	0	0	0.08	0	0	0.06	0	0	0.01
Gujarat	438	8.6	9.1	3.99	2.3	2.2	2.47	3.0	3.0	0.23
Haryana	9	1.7	1.7	0.61	2.6	2.9	3.14	1.5	4.3	0.96
Himachal Pradesh	482	1.8	3.3	2.23	0.3	0.4	0.03	0	0.2	0
Jammu and Kashmir	1 921									
Karnataka	1 672	10.6	8.3	6.74	2.6	1.8	0.27	7.8	3.2	1.62
Kerala	595	7.4	10.0	3.19	1.2	0	0	1.0	1.6	1.78
Madhya Pradesh	4 237	32.6	13.1	8.68	6.2	1.8	9.62	5.7	1.5	2.32
Maharashtra	1 503	20.0	16.0	5.45	2.9	6.7	4.32	7.6	5.8	0.70
Manipur	566	0.9	0.8	0.37	0.1	0	0	0.2	0	0.11
Meghalaya	646	1.0	0.9	0.40	0.1	0	0	0.2	0	0.12
Mizoram	399	0.3	0.2	0.10	0	0	0	0.1	0	0.03
Nagaland	571	0.7	0.6	0.28	0.1	0	0	0.1	0	0.08
Orissa	1 370	26.0	11.2	4.56	4.3	0.6	3.33	7.6	0.4	0.76
Punjab	6	1.9	1.9	1.31	3.0	3.4	2.99	1.8	5.0	1.63
Rajasthan	87	9.8	4.3	7.05	7.0	2.1	4.76	2.8	0.8	0.51
Sikkim	230	0.3	0.2	0.04	0	0	0	0.1	0	0.03
Tamil Nadu	418	17.9	8.5	6.31	7.5	2.0	1.49	13.9	2.5	1.49
Tripura	95	1.6	1.4	0.67	0.2	0	0	0.3	0	0.20
Uttar Pradesh	1 746	16.6	21.9	15.56	37.2	17.2	23.50	5.6	17.3	6.98
West Bengal	130	20.3	4.4	4.52	9.0	0	4.85	10.5	0	7.74
Union Territory										
Andaman and Nicobar Islands	449	–	–	–	–	–	–	–	–	–
Dadra and Nagar Haveli	6	–	–	–	–	–	–	–	–	–
Total	26 290	–	–	–	–	–	–	–	–	–

REDB - Rural Energy Database India of TERI; IREP - Integrated Rural Energy Programme, NCAER - National Council for Applied Economic Research

Sources

1 Prasad A and Bhattacharya P. 1998. **National wood fuel energy front.** ***Proceedings of National Wood Expert Consultation on Wood Energy in Curricula of Forestry Training*** **and Education in India.** Dehra Dun: Indira Gandhi National Forest Academy.

2 NCAER. 1985. **Domestic fuel survey with special reference to kerosene.** New Delhi: National Council for Applied Economic Research.

3 ***Eighth Five-Year Plan (1992–97).*** New Delhi: Planning Commission, Government of India.

4 Sinha C S, Sinha S, and Joshi V. 1998. **Energy use in rural areas of India, setting up a rural energy database.** *Biomass and Bioenergy* **14**(5/6): 489–503.

Table 3.05 Fuelwood demand (million tonnes/year) and total availability of land (million hectares)

Region	*Estimated fuelwood consumption 2004/05*	*Fuelwood needed to substitute use of dungcake*	*Total*	*Estimated fuelwood requirement to be met through plantation*	*Open degraded forests*	*Cultivable wasteland*	*Barren and uncultivable land*	*Permanent pastures and other grazing lands*	*Farm periphery*	*Total land available for plantation*
North	81.0	32	113.0	106.5	0.992	8.587	4.664	3.326	1.679	19.248
East and North-East	60.0	8	68.0	63.5	2.220	0.858	4.202	0.863	1.184	9.327
South	106.5	8	114.5	110.0	1.790	1.903	5.123	2.413	1.206	12.435
West	68.0	12	80.0	73.0	3.466	4.869	6.514	5.319	1.333	21.501
Total	315.5	60	375.5	353.0	8.468	16.217	20.503	11.921	5.406	62.515

Source

Prasad A and Bhattacharya P. 1998. **National wood fuel energy front.** In *Proceedings of National Wood Expert Consultation on Wood Energy in Curricula of Forestry Training and Education in India*. p. 38. Dehra Dun: Indira Gandhi National Forest Academy.

Table 3.06 Sources of supply of woodfuels in India

Source	*Details*	*Total fuelwood contribution* (million tonnes/year)
Forests	Felling of trees	19.0
	Lopping of twigs and branches	42.0
	Logging wastes	9.5
Shrubs on degraded lands and roadsides	–	46.0
Tree planting on 17 million hectares during 1975-90 through social and farm forestry programmes	Tops, twigs, small branches, and poles	40.0
Homestead gardens	Twigs and branches	16.0
Total		172.5

Source
Majumdar N B. 1998. **Integrating wood energy subjects into forest management curriculum.** In *Proceedings of National Experts Consultation on Wood Energy in Curricula of Forestry Training and Education in India.* Dehra Dun: Indira Gandhi National Forest Academy.

Table 3.07 Demand-supply situation of industrial wood in round-wood equivalent **(million cubic metres)**

	Demand			*Supply*			*Gap*			*Demand unfulfilled*
Year	*Hardwood*	*Softwood*	*Total*	*Hardwood*	*Softwood*	*Total*	*Hardwood*	*Softwood*	*Total*	(%)
2000	31	57	58	14	15	29	-17	-12	-29	-50
2010	48	47	95	14	36	50	-34	-9	-45	-49
2020	69	84	153	24	38	62	-45	-46	-91	-59

Source
Ganguli B N. 2000. **Forest management options beyond 2000: issues and opportunities for India.** Paper presented at *India's Forests Beyond 2000.* Organized by the Common Wealth Association (India) and Indian Council of Forestry Research and Education at New Delhi, India, 19-21 April 2000.

ble 3.08 Demand and availability of wood/timber from all sources under accelerated management option (million cubic metres)

	2000			2010			2020		
	Hardwood	*Softwood*	*Total*	*Hardwood*	*Softwood*	*Total*	*Hardwood*	*Softwood*	*Total*
mand	31.00	27.00	58.00	47.00	48.0	95.00	69.0	84.0	153.0
urces of supply									
Natural forests	14.00	–	14.00	–7.00	–	7.00	–	–	–
Dense (40% up)	–	–	–	12.00	–	12.00	24.0	–	24.0
Degraded									
(Joint Forest Management)	–	–	–	3.45	–	3.45	7.0	–	7.0
Degraded (regeneration)	–	–	–	3.60	–	3.60	7.0	–	7.0
Plantations									
Long rotation	–	–	–	0.70	–	0.70	1.4	–	1.4
Short rotation	–	9.24	9.24	– 9.0	–11.0	20.00	– 15.3	11.0	26.3
Social and agroforestry	–	5.80 16.80	5.80	–	7.0 28.0	23.80	–	–7.0	35.0
Total	14.00	15.00	29.00	26.75	43.8	70.55	40.0	61.3	100.7
pply	17.00	12.00	29.00	20.25	4.2	24.45	29.0	22.5	52.0
mand gap (%)	45.16	55.55	50.00	43.00	9.0	25.70	42.0	26.7	34.0

tes

Annual increment for fast-growing species for clonal plantation and social forestry is based on field data in 11 states.

With the expected improvement in harvesting techniques in the coming years of natural conversion, percentage from gross volume to round volume has been taken as 60 for harvesting in forest area and 70 in plantations.

The figures in are production from pre-2000 year treatment areas, which have been taken as 50% in the table due to reduction on completion of three harvests and replanting under new approach.

urce

nguli B N. 2000. **Forest management options beyond 2000: issues and opportunities for India.** Paper presented at ***India's Forests Beyond 00.*** **Organized by the Common Wealth Association (India) and Indian Council of Forestry Research and Education at New Delhi, India, 19–21 ril 2000**

Table 3.09 The extent (%) of regeneration in forests in selected states and union territories: 1987 and 1995

State / Union Territory	*Forest area with inadequate/ no regeneration (%)*	
	1987	*1995*
State		
Assam	89.70	84.8
Arunachal Pradesh	76.80	68.6
Bihar	54.01	32.5
Gujarat	86.13	–
Goa	67.93	–
Haryana and Punjab (Shivaliks)	–	90.0
Himachal Pradesh	69.10	88.8
Jammu and Kashmir	98.97	90.2[a]
Karnataka	98.10	62.6
Madhya Pradesh	49.95	75.0
Maharashtra		89.0
Manipur	8.42	90.0
Meghalaya	57.60	94.0
Nagaland	89.40	–
Orissa	85.66	66.0
Rajasthan	91.80	90.6
Sikkim	83.81	47.0
Tripura	–	69.0
Uttar Pradesh	80.55	79.4
West Bengal	70.80	15.0
Union Territory		
Andaman and Nicobar Islands	31.70	–
Dadra and Nagar Haveli	–	81.0

[a] only in Jammu

Source

FSI. 1988 and 1996. *The State of Forests Report.*
Dehra Dun: Forest Survey of India.

Table 3.10 Intensity and extent of grazing in forests: 1991 to 1993

State / Union Territory	*Incidence of grazing: % forest area affected* *High*	*Medium*	*Light*	*Total*
State				
Arunachal Pradesh	1.50	10.35	27.95	39.80
Assam	6.70	13.70	29.10	49.50
Bihar	4.60	28.50	47.20	80.30
Himachal Pradesh	22.75	30.00	34.10	86.85
Karnataka	5.87	4.73	9.93	20.53
Manipur	5.00	11.00	30.00	46.00
Maharashtra	25.85	37.05	22.60	85.50
Madhya Pradesh	33.50	32.50	19.00	85.00
Meghalaya	4.10	17.80	42.20	64.10
Orissa	19.90	29.65	30.95	80.50
Rajasthan	56.50	28.40	11.50	96.40
Sikkim	4.80	20.10	29.60	54.50
Tripura	13.50	30.00	37.00	80.50
Uttar Pradesh	16.87	30.55	36.00	83.42
West Bengal	24.70	39.80	23.02	87.52
Union Territory				
Dadra and Nagar Haveli	10.00	86.00	4.00	100.00

Source

FSI. 1995. ***The State of Forests Report 1994***. Dehra Dun: Forest Survey of India.

Table 3.11 Wood consumption (**million cubic metres**): 1987 to 2010

Year	*Consumption*	*Sustainable production*	*Gap*
1987	235.0	40.0	195.0
1994	255.3	–	–
1997	260.0	52.6	207.4
2010	344.5	–	–

Source

TERI 1998. **Forest resources.** In *Looking Back to Think Ahead*, pp. 95–138, edited by R K Pachauri and P V Sridharan. New Delhi: Tata Energy Research Institute. 346 pp.

Table 3.12 Scenario of industrial wood (**million cubic metres**): 1947 and 1997

Year	*Requirement*	*Production*	*Gap*	*Fraction met*
1947	2.5	2.5	0	100.0
1997	34.0	14.0	20.0	41.0
Rise (%)	1260.0	460.0	–	–

Source
TERI. 1998. **Forest resources.** In *Looking Back to Think Ahead*, pp. 95–138, edited by R K Pachauri and P V Sridharan. New Delhi: Tata Energy Research Institute. 346 pp.

Table 3.13 Changes in area under forests (**million hectares**): 1987 to 1999

Class of forest	*1987*	*1989*	*1991*	*1993*	*1995*	*1997*	*1999*
Dense forest	36.14	37.85	38.50	38.56	38.58	36.73	37.74
Open forest	27.66	25.74	25.03	25.03	24.99	26.13	25.51
Mangrove	0.40	0.42	0.42	0.42	0.45	0.48	0.49
Scrub area	7.68	6.61	5.89	5.89	6.05	5.72	5.19

Source
FSI. ***The State of Forests Report*** *(various issues)*. Dehra Dun: Forest Survey of India.

Table 3.14 Future scenario: 1997 and 2019

Parameter	*1997*	*2019*
Area under forest cover and tree cover (million hectares)	71	74
Sustainable production of timber (million cubic metres)	26	41
Sustainable production of fuelwood (million cubic metres)	53	64

Source
TERI. 2001. **DISHA (Directions, Innovations, and Strategies for Harnessing Action) for Sustainable Development.** New Delhi: Tata Energy Research Institute (Report No. 97 EE 12).

LOCAL AND GLOBAL ENVIRONMENT

Environment

At a glance

- Annual average levels of total suspended particulate matter in six of India's largest cities are at least three times the WHO (World Health Organization) standard. More than 90% of the national monitoring stations record particulate concentrations exceeding 75 $\mu g/m^3$, the recommended standard issued by the WHO.
- While two- and three-wheelers contribute heavily to emissions of hydrocarbons and oxides of nitrogen, petrol-driven vehicles contribute over 85% of total carbon monoxide emissions and diesel-driven vehicles contribute over 90% of the emissions of oxides of nitrogen in metropolitan cities.
- The Ministry of Environment and Forests estimates that industrial pollution contributes more than one-third of the total pollution in rivers and other bodies of water. According to the Central Pollution Control Board, 1532 grossly polluting industries discharge effluents into water courses.
- Per capita municipal solid waste generation is increasing over the years at the rate of 1.33%.
- At present, the hazardous waste generation from the industrial sector is 7.2 MT (million tonnes) annually, of which approximately about 1.4 MT is recyclable waste, 0.1 MT is incinerable, and 5.2 MT is meant for disposal in landfills.

Introduction

Most of the environmental problems that confront mankind today are connected to the use of energy in one way or another. Degradation and low accessibility of water resources, industrial pollution, and urban congestion are the major environmental issues that deserve high priority for India, besides land and soil resources and deforestation (UNEP 1997).

Awareness of the environmental effects of energy production and its use in the transport, industrial, and domestic sectors is on the rise. The concern over environmental degradation brought about by increased consumption of fuels such as coal and oil has been growing. The combustion of fuels in the industrial and transport sectors is the major source of emissions, but domestic sources also pose potential health hazards.

The total costs of environmental degradation and pollution are unknown. The calculations performed by the World Bank add up to 4.5% of the gross domestic product (World Bank 1996). These are rough estimates and should be viewed as lower bounds, given the exclusion of several categories of cost.

Environmental laws and regulating agencies

A well-developed framework for environmental legislation did not exist in India until after the 1972 UN Conference on Human Environment (Stockholm) took place. In 1976, the constitutional sanction was given to environmental concerns through the 42nd Amendment, which incorporated them into the Directive Principles of State Policy (Article 48A) and Fundamental Rights and Duties (Article 51A[g]) (Thakur 1993).

Before a body of legislation focusing directly on the environment began to be developed, there were a number of older laws, such as the Indian Penal Code (1860), that addressed certain environmental concerns. Kolkata adopted anti-smoke legislation in 1863, well before many European industrial centres. The Bengal Smoke Nuisance Act followed suit in 1905 (Anderson 1995). The Indian Easements Act (1882), which deals with rights in relation to the pollution of water, is yet another example.

The Water (Prevention and Control of Pollution) Act, 1974, attempted to address pollution issues at a national level in an integrated manner. (Please refer to Table 4.01 for a comprehensive list of environmental as well as environment-related laws.) The Air (Prevention and Control of Pollution) Act, 1981, and the umbrella legislation brought out in 1986, namely, the Environment Act, covered the gamut of pollution problems, laying down the standards for pollution levels, etc. It was under the Water Act that the CPCB (Central Pollution Control Board) and the SPCBs (state pollution control boards), and pollution control committees in the union territories were set up (CPCB 1998). They form a network of bodies responsible for controlling and monitoring environmental degradation.

The National Council for Environmental Policy and Planning, within the Department of Science and Technology, was set up in 1972 under the influence of the Stockholm Declaration brought out in the same year. It gradually evolved into the full-fledged MoEF (Ministry of Environment and Forests). This is now the apex administrative body responsible for regulating and ensuring environmental protection in the country. From Figure 1, which lays out the organization of the environment sector, it can be seen that the MoEF and the pollution control boards form the regulatory and administrative core of the sector (MoEF 1997).

The other bodies, namely, the ministries and departments, have within their supervision schemes and specified functions related to environmental management. The Ministry of Non-conventional Energy Sources, for instance, deals with the development of alternative sources of energy. There are a number of government and non-government research institutes and laboratories that are involved in monitoring, reporting, and studying environmental pollution.

There are numerous other bodies that may not be directly linked to the environment sector but form an integral part of it. The Eleventh Schedule of the 73rd Constitutional Amendment made in 1992 is related to the panchayats and addresses issues of environmental protection and conservation. Panchayats are bestowed with responsibilities in the areas of soil conservation, water management, watershed development, social and farm forestry, drinking water, fuel and fodder, non-conventional energy sources, and maintenance of community assets. The 74th Constitutional Amendment Act, 1992, added the Twelfth Schedule to the constitution, which pertains to urban local bodies. It relates to their constitution as well as specifies their functions of protection of the environment and promotion of ecological effects.

A policy framework that complements the above laws and constitutional sanctions has also been developed. Referred to here are the two policy statements of 1992, namely the *Policy Statement for Abatement of Pollution* and the *National Conservation Strategy and Policy Statement on Environment and Development* brought out by the MoEF. The former draws attention to the changed stance within the environment sector such that the development and promotion of voluntary initiative for protection and improvement of the environment, through the use of incentives, is simultaneous to the development of the regulatory and legislative framework. These incentives may be financial with the intention of encouraging cleaner technologies and production practices and deterring the use of harmful and polluting practices.

Following close on the heels of the above two policy statements came the Environment Action Programme (MoEF 1993). The stated objective of the programme is to prepare a 'blueprint' for integrating environmental concerns into the development process. The intention is to formulate a blueprint that is dynamic and holistic and promotes a decentralized system of environmental management. The formulation of a comprehensive national policy on the environment is currently in process in the government. The National

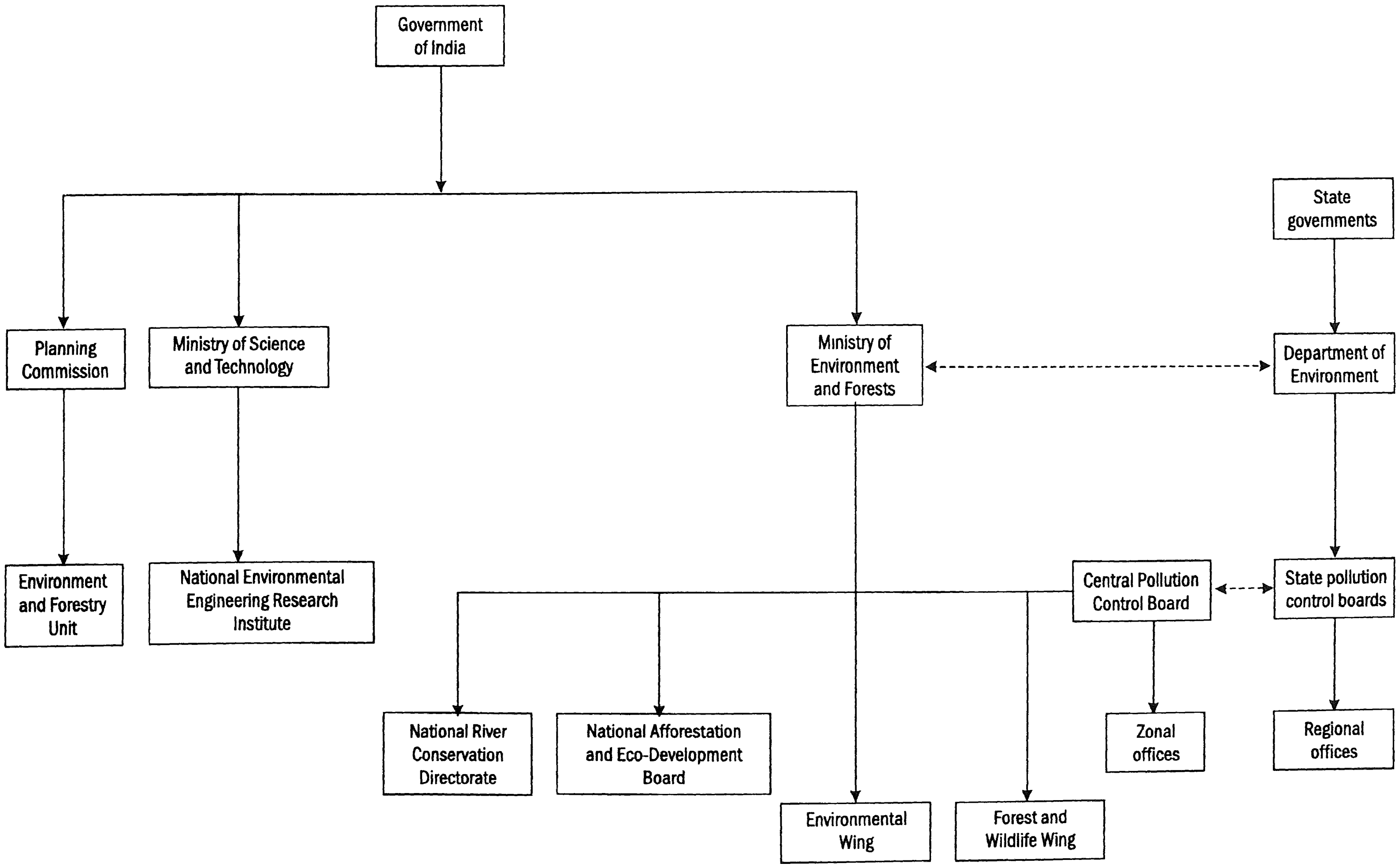

Government of India
Planning Commission
Ministry of Science and Technology
Ministry of Environment and Forests
State governments
Department of Environment
Environment and Forestry Unit
National Environmental Engineering Research Institute
Central Pollution Control Board
State pollution control boards
National River Conservation Directorate
National Afforestation and Eco-Development Board
Environmental Wing
Forest and Wildlife Wing
Zonal offices
Regional offices

Figure 1 The organization of the environment sector in India
Source MoEF (1997)

Water Policy was adopted in 1987, with the aims of ensuring optimum though environmentally sound utilization of water resources, and dealing with the high pollution levels.

International agreements and conventions also come under the ambit of environmental law. India, for instance, is a signatory to the Basel Convention (1989) on the control of transboundary movement of hazardous waste and its disposal (CII 1999). Being a signatory, India has made efforts to amend its earlier rules on waste management.

Environment and development

The Ninth Five-Year Plan (1997–2002) focuses on sustainable development as one of its objectives. This implies realizing the symbiotic relationship between the processes of environmental protection and improvement and that of development. The budgetary outlays are planned accordingly. The expenditure of the MoEF in the Eighth Plan was 16 319 million rupees (current prices) as against the allocation of 12 000 million rupees (1992 prices). In 1998/99, however, the MoEF spent 5730 million rupees against the allocated 8200 million rupees. This seems to indicate that the amount of budgetary support cannot be taken to be an indicator of the importance – or the lack of it – given to environmental concerns.

The need to fulfil the stated Ninth Plan objective of integrating such concerns into the process of development grows stronger. Table 4.02 lists, in this context, the projects waiting to get environmental clearance from the government.

The costs of degradation that result from the above activities are very high. The findings of TERI's *GREEN India 2047* study (TERI 1999) are as follows.

- The economic loss due to soil degradation was 89–232 billion rupees annually, a loss of 11%–26% of agricultural output.
- Air pollution has significant health impacts. For each urban resident, it comes to about 600–1500 rupees a year, and for each slum dweller, it could be as high as 2000–7400 rupees a year.
- The incremental annual cost of ensuring safe drinking water and adequate sanitation facilities to all is 122 billion rupees. As a contrasting estimate, the World Bank estimated health impacts related to water quality to be worth 107 billion rupees.

Environmental standards

Standards for ambient air quality, water quality, noise levels, vehicles with controlled pollution levels, specific industries, etc. are developed to monitor and regulate pollution levels. Pollution levels all over the country are being monitored by various agencies and the status of pollution control is improving due to increasing efforts on the part of the government and rising awareness amongst the industries. During the course of the year, more standards have been introduced, regarding which notifications have been issued by the MoEF. These are added under the relevant sub-sections.

Ambient air quality standards

Faced with the growing problems of air pollution, a number of countries have established ambient air quality standards to protect the environment. India too, under Section 16(2)(h) of the Air (Prevention and Control of Pollution) Act, 1981, has enforced ambient air quality standards. Till early 1994, these were based on an eight-hourly averaging time only. In April 1994, these standards were revised to 24-hourly standards. The national ambient air quality standards are prescribed for three distinct areas: (1) industrial; (2) residential, rural, and other; and (3) sensitive. In a notification brought out in November 1998, the standards for ammonia have been added to the national ambient air quality monitoring standards (Tables 4.03 and 4.04).

Of late, noise has been recognized as a pollutant, which, until recently, was considered only as a nuisance. The CPCB has notified the ambient noise standards in 1987 under Section 20 of the Air (Prevention and Control of Pollution) Act, 1981. In terms of additions to the standards as specified in Table 4.05, noise standards for 15–500 kVA generator sets / stationary diesel generator sets have been notified as lying between 85 and 90 dB (A). Studies of noise levels conducted in a few major cities indicate that these levels are barely within limits in industrial zones, but due to vehicular noise, the pollution limits in residential, silence, and commercial zones are being challenged more and more everyday (MoEF 1999).

Water quality standards

Drinking water standards for India were set up by the Indian Council of Medical Research. These are almost similar to the WHO (World Health

Organization) drinking water standards. The United States Public Health Service has even more stringent standards.

For industries, surface water is the main source for drawing water for industrial purposes and discharging effluents. The water quality in surface water bodies depends on discharges at various stretches. Based on water quality criteria, the CPCB has designated water uses for all Indian rivers. This is done through classification of surface water into five categories, namely A, B, C, D, and E, in decreasing order of quality (Table 4.06).

Discharges of industrial effluents are regulated through Indian Standards Codes–IS:2490 (1974) for discharges into inland surface waters, IS:3306 (1974) for discharges into public sewers, and IS:3307 (1974) for discharges on land for irrigation (refer to Table 4.07 for general effluent discharge standards. For industry-specific standards, see Tables 4.08–4.13, and Table 4.14 for thermal power plants.)

Recently, water quality standards for coastal waters' marine outfalls have been specified.

Industrial emission standards

Industries consume energy mostly in the form of fuel for combustion and for feed material in a few cases. Air-borne emissions from various industries are a cause for major concern. These emissions are of two forms: (1) particulate emissions such as SPM (suspended particulate matter), and (2) gaseous emissions such as sulphur dioxide, oxides of nitrogen, and carbon monoxide. Liquid effluents, generated from certain industries, containing organic and toxic pollutants are also a cause for serious concern. Heavily polluting industries have been identified and are included under the 17 categories of highly polluting industries for the purpose of monitoring and regulating pollution.

The MoEF has, over the past two decades, developed standards for regulating emissions from various industries and set emission standards for all polluting industries including thermal power stations. Among the most recent additions are the standards for gas-/naphtha-based thermal power plants (Tables 4.15–4.17). Industry-specific standards are also specified for iron and steel plants, cement plants, etc. (Tables 4.18–4.25). Most of the air quality emission standards include permissible limits for SPM and in a few cases sulphur dioxide (where it is the prime pollutant) whereas no standards for oxides of nitrogen and carbon monoxide are specified. The health risks of radioactive exposures can be fatal as has been recorded in the past. The International Commission on Radiological Protection has specified the standard for maximum permissible radioactive dose as one millisievert (excluding natural background levels).

Vehicular emission standards

The share of vehicular pollution in urban areas is reaching serious proportions. Emission factors for different vehicles are given in Table 4.26. Vehicular emission control is also increasingly gaining attention. Vehicular emission standards were first set in 1986 by the CPCB for both petrol- and diesel-driven vehicles. These were later revised in 1987 and 1989. The prevailing standards for petrol-driven vehicles for carbon monoxide are 3% for two- and three-wheelers and 4.5% for four-wheelers (Table 4.27). The standards for diesel-driven vehicles specify limits for smoke as 65 Hartridge units (Table 4.28).

These, however, are emission standards with reference to volume of air. They do not constitute mass emission norms, the first stage of which came out in 1991 for petrol vehicles and in 1992 for diesel vehicles. The next stage of mass emission norms, Euro I, is to be initiated from 2000. And compliance with the next stage, the one enforced in Europe at present – Euro II norms – is to be initiated in 2005. On 29 April 1999, the Supreme Court brought forward the introduction of both stages of emission norms by ordering a move to disallow registration of all private non-commercial vehicles in the NCR (National Capital Region) failing to conform to Euro II fuel emission norms from 1 April 2000. The order forced automobile manufacturing companies to meet Euro I norms by 1 June 1999 and Euro II norms by 2000. Tables 4.29 and 4.30 compare standards specified at all of the above stages.

To conform to the Euro I and II norms, the quality of petrol and diesel has to adhere to specific fuel properties. These must include, initially, reduction or substitution of lead in petrol and reduction of sulphur in petrol and diesel. Also essential would be a complete or near-complete elimination of sulphur, aromatics, and heavy oils in diesel, and lead in petrol by using an oxygenated supplement like methyl tertiary butyl ether. However, there are no references to fuel quality in the Supreme Court order, although fuel specifications are as integral to the shift to Euro norms as the technology used by the car manufacturers. Also, they hold particular importance for India at present as the Bureau of Indian Standards's specifications for petrol and diesel quality that exist as of now do not enable emissions that are up to the Euro standards—neither Euro I nor Euro II. They were set before Euro norms came into prominence in India (Bose 1999).

The early enforcement of the Euro norms has been preceded by a number of measures being introduced in the NCR recently. For instance, the Supreme Court has also taken measures such as restricting the plying of commercial vehicles like trucks in the daytime. Other measures pertain to the introduction of unleaded petrol, which has now been made available in 42 major cities. By 2000, it will be made available throughout the country. As of now, low-lead petrol with a maximum lead content of 0.15 g/litre has been introduced throughout the country. Low-sulphur diesel, with a sulphur content of 0.5% or less, has been introduced in the four metros of Chennai, Delhi, Kolkata, and Mumbai from 1996. In Delhi and the Taj Trapezium area, the sulphur content in fuel has been further reduced. Compressed natural gas has been introduced for some categories of commercial vehicles.

The MoST (Ministry of Surface Transport) stipulated, in a notification brought out in 1998, that all four-wheeled petrol-driven vehicles registered after August 1998 in specified cities were to be fitted with catalytic converters. Emission norms for passenger cars fitted with catalytic converters were to be 50% lower than for cars without them (Table I).

Two-stroke engine vehicles are among the most polluting categories of vehicles. In 1998, the standards of the respective oils were specified, to be effective from April 1999. Also, pre-mixed fuel (petrol and oil) is being made available at petrol stations. Expansion of the availability of premixed oil dispensers (petrol and 2T oil) shall be undertaken along with a ban on the supply of loose 2T oils at petrol stations and service garages.

Table I Emission norms for petrol-driven vehicles, with reference to catalytic converters

	Emission standards for petrol-driven four wheelers (g/km)	
Pollutant	*Without catalytic converter*	*With catalytic converter*
Carbon monoxide	8.68-12.40	4.36-6.20
Hydrocarbons + oxides of nitrogen	3.00-4.36	1.50-2.18
Total (carbon monoxide + hydrocarbon + oxides of nitrogen)	11.68-16.76	5.84-8.38

Source MoEF (1998)

One of the most significant lacunae in rules for controlling vehicular emissions was the insufficient consideration given to older vehicles plying on the roads, with older or at times obsolete, and thus highly polluting, technology. This is now being given its due importance as government bodies as well as the Supreme Court come down hard with a programme to phase them out.

Hazardous Waste Rules

The MoEF has framed the Hazardous Wastes (Management and Handling) Rules, 1989, under the Environment (Protection) Act, 1986. It brought out a guide for the manufacture, storage, and import of hazardous chemicals in 1989 and set guidelines for the management and handling of hazardous wastes in 1991. The Manufacture, Storage, and Import of Hazardous Chemicals Rules list 434 toxic flammable and explosive chemicals, which require careful regulation.

The Hazardous Wastes Rules list 18 types of waste categories with their regulatory quantity, which, if exceeded by any industry has to comply with the various management and handling rules. The MoEF has notified the Hazardous Wastes (Management and Handling) Amendment Rules, 2000, in January 2000 with a view to provide guidelines for import and export of hazardous waste in the country and also provides a list of waste to be regulated for import and export by these rules. The waste categories' list has been made more comprehensive, eliminating all threshold values for hazardous waste, and baring the requirement for treatment and disposal instead of the identification of processes generating these hazardous wastes.

Bio-medical Waste Rules

In 1998, the MoEF promulgated the Bio-medical Waste (Management and Handling) Rules under sections 6, 8, and 25 of the Environment

(Protection) Act, 1986. They contain guidelines with regard to the disposal, segregation, transport, etc. of infectious wastes generated by treatment of, as well as research activities related to, human beings or animals. Thus, it is the responsibility of hospitals, blood banks, pathological laboratories, etc. to handle such waste without any adverse effect to human health or the environment. (Refer to Table 4.31 for the various categories of bio-medical waste specified.)

Municipal Solid Waste Rules

The Municipal Wastes (Management and Handling) Rules, 2000, have been notified under sections 3, 6, and 25 of the Environment (Protection) Act, 1986. These rules are an attempt to provide a set of rules and responsibilities for all the municipalities governing collection, transportation, treatment, and disposal of municipal solid waste in a scientific manner. The municipalities have to adhere to the compliance criteria established and furnish its annual report in a prescribed format to the District Magistrate or the Deputy Commissioner, who would forward it to the SPCB or the Pollution Control Committee as the case may be.

Recycled Plastics Manufacture and Usage Rules

The Recycled Plastics Manufacture and Usage Rules, 1999, have been notified by the MoEF under sections 3 and 25 of the Environment (Protection) Act, 1986. The rules prohibit the use of carry bags or containers made of recycled plastics for storing, carrying, and packing the foodstuff. It also defines the conditions for manufacturing carry bags and containers made of plastics.

Draft Battery Rules

The Draft Battery (Management and Handling) Rules, 2000, have been introduced under sections 6, 8, and 25 of the Environment (Protection) Act, 1986. They contain a set of responsibilities for every manufacturer, importer, re-conditioner, assembler, dealer, recycler, re-smelter, auctioneer, consumer, and bulk consumer involved in the manufacture, processing, sale, and purchase of batteries.

Environmental scenario

India is one of the 10 most industrialized countries in the world. Increasing urbanization, industrialization, deforestation, transportation, and high-intensity agriculture are some of the major causes of environmental problems being faced by the country.

Air pollution

Although India has made great strides in recent years in managing environmental issues, urban environmental degradation is heading towards a crisis. Six of the largest cities in India have severe air pollution. Annual average levels of total SPM in these cities are at least three times the WHO standard. More than 90% of the national monitoring stations record particulate concentrations exceeding 75 $\mu g/m^3$, the recommended standard issued by the WHO.

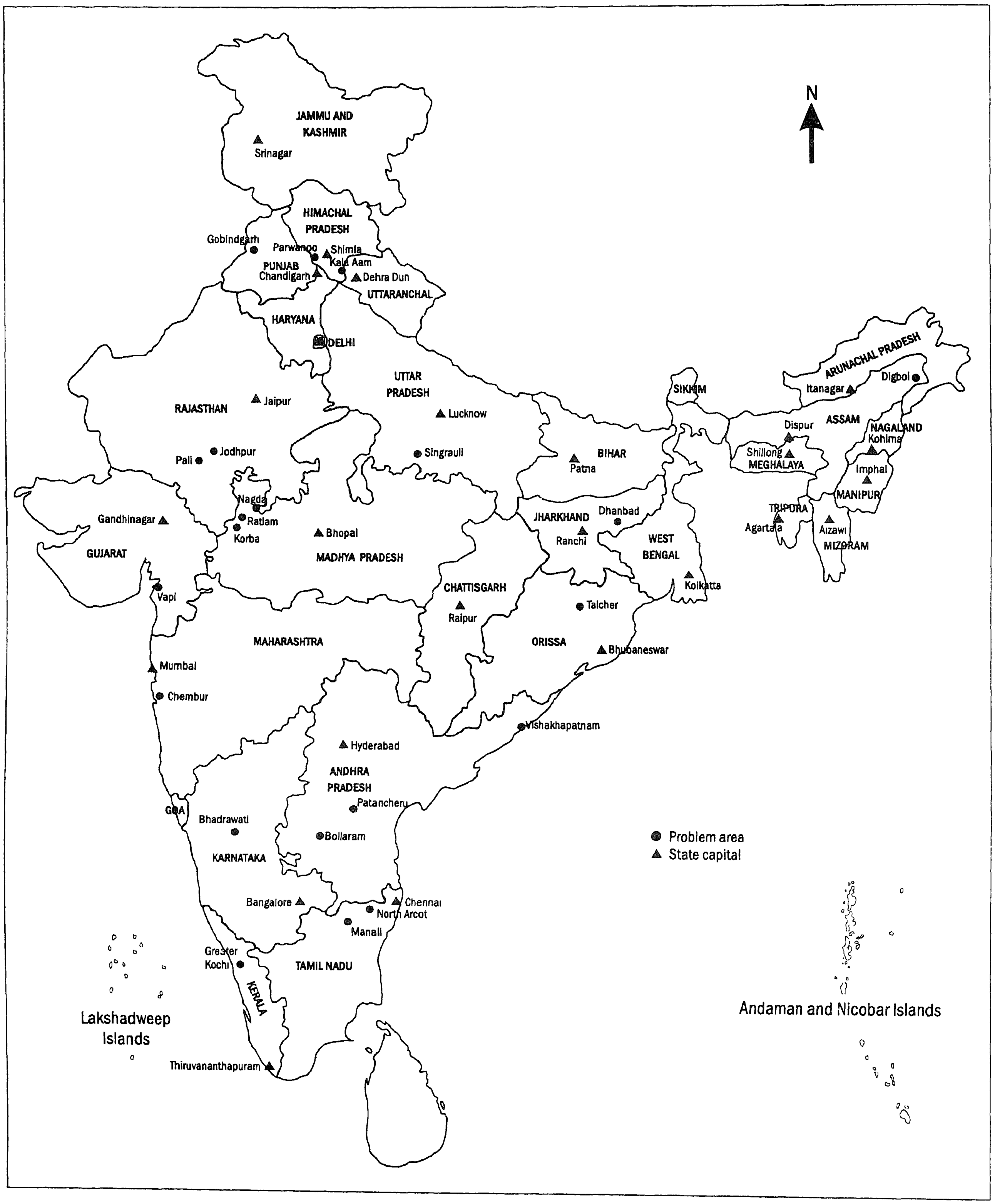
The CPCB has been regularly monitoring the ambient air quality at 290 locations spread over 92 cities/towns, and water quality in all the major rivers at 402 locations under MINARS (monitoring Indian national aquatic resources systems), 51 locations under GEMS (global environmental monitoring systems), 27 locations under the GAP (Ganga Action Plan), and 134 locations for groundwater.

The monitoring data revealed that the status of air quality was bad in Howrah, West Bengal, in 1994, and worse in Gajraula, Uttar Pradesh, in 1993. The CPCB has also identified 24 locations as problem areas in the country (Map 1) (CPCB 1995a). Two new problem areas have emerged, namely, Kala Aam and Parwanoo, both in Himachal Pradesh (R C Trivedi, Telephonic Communication). Table 4.32 compares the status of cities with respect to highly polluted air quality levels. Average noise levels in various metropolitan cities are given in Table 4.33.

The emissions from industries vary, as there is a wide range of fuel types used and industrial processes. However, the important pollutants from industries are SPM, carbon monoxide, sulphur dioxide, and oxides of nitrogen.

Industry

Industrial growth has been accompanied by a variety of environmental problems. Whereas industrial output grew fourfold between 1963 and 1991, toxic releases grew sixfold as shown in Table II (World Bank 1996). In India, there were 1551 industries falling under the 17 categories of highly polluting industries as on 31 March 1996. The status of pollution control in these industries



Map 1 Problem areas in India with respect to air quality
Source CPCB (1995a)

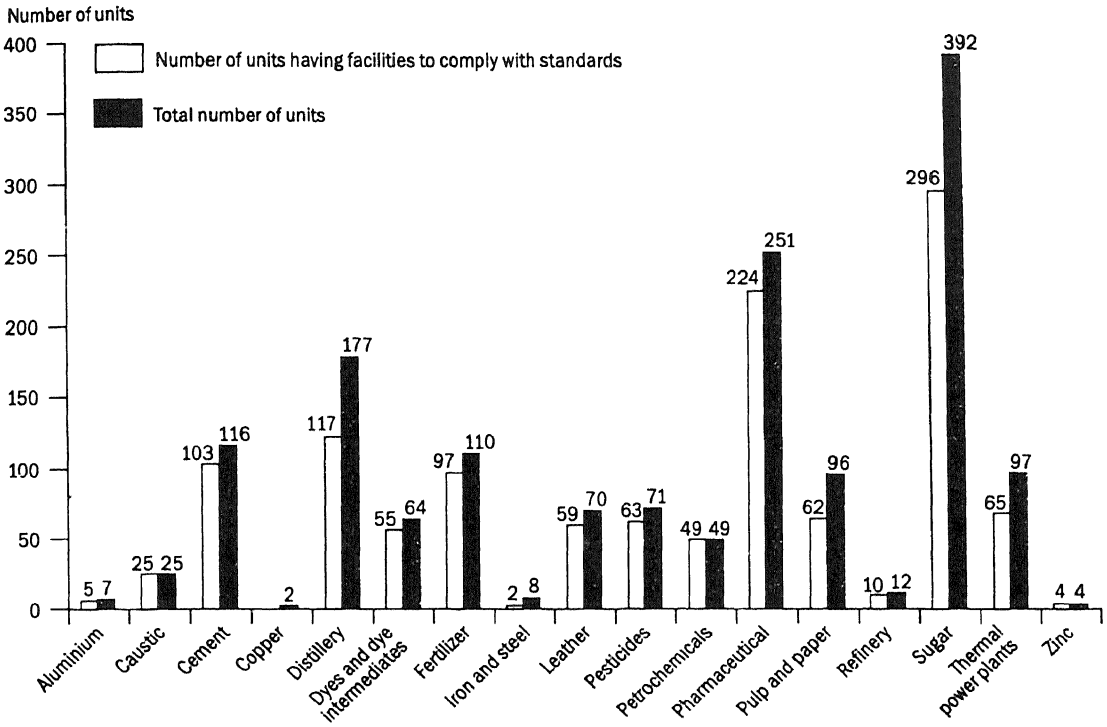


Figure 2 Status of compliance by 17 categories of highly-polluting industries
Source CPCB (1997)

is given in Figure 2 (CPCB 1997). (More details are given in Table 4.34, and Table 4.35 contains a statewise summary regarding these 17 categories.) Thermal power, sugar, pulp and paper, and distillery emerge as the major defaulters in meeting air pollution standards.

Table II Industrial contribution to pollution by sub-sector

	Share of total pollution (%)		
Sector	*Particulates*	*Sulphur*	*Nitrogen*
Industrial chemicals	8	11	15
Iron and steel	23	2	5
Non-ferrous metals	3	1	0
Other chemicals	1	0	1
Food products	11	4	8
Paper and pulp products	4	15	11
Non-metallic mineral products	32	3	10
Petroleum refineries	6	31	21
Textiles	6	30	23

Source World Bank (1996)

Power

Thermal power constitutes about 72% of the total installed power generation capacity. Coal-based thermal power generating capacity of the country by the end of 1994/95 was 58 169 MW. Increasing reliance on thermal power leads to many environmental problems. India's coal is very high in ash content (35%–40%), the disposal of which is a major problem. Further, the quality of coal available to the thermal power stations has declined considerably. The poor quality of coal results in greater consumption of coal per unit of electricity generated and, therefore, leads to higher emissions per unit of generation and increased problems of ash disposal.

The MoEF, in a notification issued in 1997, made it imperative for TPPs (thermal power plants) located beyond 1000 km from the coal pit-head, or in urban, sensitive or critically polluted areas, to use coal with an ash content lower than 34%. The coal used by such TPPs after 1 June 2001, the date specified, is to be beneficiated coal, i.e. coal containing a lower ash content in the raw coal obtained through physical separation or through the washing process.

Transport

Vehicular emissions are assuming alarming proportions in urban areas. The salient problems associated with vehicular pollution are emissions from older, ill-maintained vehicles plying on the road.

Emissions causing concern are carbon monoxide, oxides of nitrogen, unburned hydrocarbons, and particulates. Petrol-driven vehicles are a major source of carbon monoxide emissions, contributing over 85%; diesel-driven vehicles contribute over 90% of emissions of oxides of nitrogen. Emission of hydrocarbon and carbon monoxide from the large two- or three-wheeler population and the emissions of oxides of nitrogen from diesel vehicles are very high. The daily pollution load generated due to automobiles in the four metropolitan cities is shown in Table III.

Even though the vehicular population is increasing at a phenomenal rate, it is still low compared to several European countries and the US. Despite this, vehicular pollution has become a serious problem in urban areas. The different factors attributable are the types of engines used, the age of vehicles, poor road conditions, and congested traffic. The fuel used is also of great importance. Also, the adulteration of fuels and use of spurious lubricants are worrying factors. The availability of pre-mixed fuels (refer to the section on vehicular emission standards) should help to deal with this problem.

A holistic approach needs to be taken to address this problem. Enforcement of the Euro II norms will have to be supplemented with more care towards fuel quality, for instance. Also, long-needed attention is finally being turned towards older vehicles plying on the roads. The road network itself is beginning to draw attention. A recently introduced bill has hiked up excise, which will be fed into investment for developing and improving the network. (For more details, see the chapter on *Transport*.)

Table III Estimated emissions of pollutants from vehicles in metropolitan cities: 1994

	Amount of pollutant (tonnes per day)					
City	*Particulates*	*Sulphur dioxide*	*Oxides of nitrogen*	*Hydrocarbons*	*Carbon monoxide*	*Total**
Delhi	10.3	9.0	126.5	249.6	651.0	1046.3
Mumbai	5.6	4.0	70.8	108.2	469.9	659.6
Kolkata	3.3	3.7	54.7	43.9	188.2	293.7
Chennai	2.3	2.0	28.2	50.5	143.2	226.3

* may not add up exactly due to rounding off

Source CPCB (1995b)

Domestic

In 1991, the World Bank rated indoor air pollution in developing countries as one of the four most critical global environmental problems. Emissions from domestic fuel consumption are also of significance since a large proportion of the population is involved in domestic cooking activities. Pollutants of concern from such sources are SPM and carbon monoxide. Cumulative exposure to such pollutants is often more damaging to health than exposure to larger sources of pollution.

Studies related to indoor air pollution show that the concentration of SPM during a cooking session varies from 3 to 6 mg/m^3 and that of carbon monoxide from 5 to 50 parts per million. Women in rural households have to cope with a daily pollution load equivalent to spending one hour in a room that has as much as 40 mg of SPM for every cubic metre of air, as against a value of 1.2–3.0 mg suggested by the WHO.

Water pollution

Water is polluted by four kinds of substances: (1) traditional organic waste, (2) waste generated from industrial processes, (3) chemical agents for fertilizers and pesticides for crop protection, and (4) silt from degraded catchments. While it is estimated that three-fourths of the volume of the waste water generated is from municipal sources, industrial waste, though small in volume, contributes over one-half of the total pollution load.

The types and sources of water contamination include 'point' sources of pollution, which usually refer to wastes being discharged from a pipe, and 'non-point' sources, which mean all other sources such as storm water runoff (which picks up oil and other contaminants from various areas), irrigation (which carries fertilizers and pesticides into groundwater), and leaks.

Pollution problems in small towns are basically associated with water. A survey of 241 Class II towns in 17 states in India undertaken by the CPCB indicates that, on an average, 90% of the water supplied is polluted. Only 1.6% of the total 'polluted' waste water gets treated (CPCB 1990). Almost all the major rivers in India are increasingly deteriorating in their water quality. The list of polluted river stretches is ranked in Table 4.36 along with possible sources of pollution. The Godavari, Krishna, and Indus rivers owe their pollution load predominantly to industrial activities. Municipal/domestic and industrial wastes are the major pollution sources of other rivers.

Industry

Industrial units located primarily in densely populated urban areas discharge their effluent untreated into surface water channels, land sites, and sewers. Reliable data regarding the share of industrial pollution in the total pollution load are hard to come by. The MoEF estimates that industrial pollution contributes more than one-third of the total pollution in rivers and other bodies of water. According to the CPCB, 1532 grossly polluting industries discharge effluents into water courses (CPCB 1996) (Table 4.37).

Proliferation of industries, particularly the small-scale units, has resulted in a concomitant rise in water pollution. Sugar, distillers, synthetic fibre, pulp and paper, soap and detergents, dye stuff, and tanneries are the major contributors to water pollution. Sugar and pulp and paper industries are the major defaulters in complying with the norms for liquid effluents. The share of different industries in surface water pollution is shown in Table IV.

Domestic sewage

Domestic sewage is the primary source of water pollution in India especially in and around large urban centres. In India, as per the census data of 1991, about 82% of the urban households had access to safe drinking water and 64% had toilet facility; the corresponding percentage for rural households stood at 56% and 9%, respectively.

A survey carried out by the CPCB in 212 cities in India reveals that the problem of waste water collection and disposal has become acute (CPCB 1990). In 45 major cities with a total population of nearly 65 million, the waste water generated is 9493 million litres per day while the sewerage system can collect and treat only 2357.48 million litres per day. The sewerage capacity forms just 25% of the total waste water generation in these cities. The report says that 'so long as major cities in India continue to discharge their waste water untreated into rivers, lakes, and ponds, no improvement is possible in the quality of water' (CPCB 1990).

Table IV Share of different industries in surface water pollution (water pollution in terms of chemical oxygen demand)

Industry	*Share* (%)
Food products	38
Industrial chemicals	29
Paper and pulp products	19
Non-ferrous metals	10
Petroleum refineries	2
Other chemicals	1
Textiles	1

Source World Bank (1996)

Agriculture

Certain agricultural practices, such as the increased use of nitrogenous fertilizers, affect water quality indirectly. Nitrate is one of the forms of nitrogen taken by plants. Through leaching, nitrate finds its way into groundwater, which is a potential threat to potable water quality (Table 4.38). The maximum permissible limit laid down by the WHO for nitrate content of drinking water is 100 mg/litre. In India, studies have shown that in some parts of the country, the nitrate content of dug wells was higher than the permissible limits.

Adverse impacts of pesticide use can also be observed in water. Pesticides are carried by irrigation water or rain and get transported into the ground to mix with groundwater reserves. This is also affected by leaching, runoff, or other related mechanisms. A long-term policy for pesticide use, including the introduction of environmentally acceptable pesticides, particularly bio-pesticides and non-persistent biodegradable ones, and integrated pest management together with the phasing out of the proven harmful toxic and persistent ones will be formulated in collaboration with the concerned ministries and infrastructure involved for its effective implementation.

Municipal solid waste

Environmental concerns are echoed in the *Executive Summary to the Ninth Five-Year Plan*. It recognizes that the health and environmental consequences of increasing population density, lack of safe drinking water, and inadequate urban sanitation have to be tackled through a proper urbanization policy with programmes for disease surveillance, epidemic control, and urban solid and liquid waste management (Planning Commission 1998).

The amount of MSW (municipal solid waste) generated in most Indian cities is increasing rapidly (Table 4.39). The per capita quantity increases with the size of the city and varies between 0.27 and 0.66 kg per capita per day. In metropolitan cities, values up to 0.61 kg per capita per day have been recorded. Per capita waste generation is also increasing over the years at the rate of 1.33% (CPCB 1999). It is roughly estimated that Indian cities and towns generate about 4000 tonnes of municipal wastes every day and almost all the wastes find their way to landfill sites which are seldom managed in an environmentally acceptable manner. Tables 4.40A and 4.40B give the characteristics of MSW generated in the major cities of the country.

The MSW generation and collection efficiency for 1994 is shown in Table 4.41 for major Indian cities. The management of MSW needs urgent attention, which includes collection, disposal, and transportation to the landfill sites. There is evidence that the performance is dismal in metropolitan cities (Table 4.42).

It is estimated that currently the hazardous waste generation from the industrial sector is 7.2 MT (million tonnes) annually, of which approximately about 1.4 MT is recyclable waste, 0.1 MT is incinerable, and 5.2 MT is destined for disposal in landfills (MoEF 2000) (Table 4.43). The industries that generate huge quantities of waste are thermal power stations and iron and steel plants. Non-ferrous metal industries, sugar, and fertilizer industries also generate large quantities. Disposal of these wastes is largely uncontrolled; dumping on public land or in MSW sites is quite common (Table 4.44).

Environment and health

Environmental pollution implies the introduction of chemicals or agents into the physical environment that either did not exist, or did not exist in the same large scale, earlier. The impact of pollution and depletion of resources such as pure air (indoor as well as outdoor), soil, and ground and surface water sources on the health of the human population is considerable, and growing. That respiratory infections and water-borne diseases are the major causes of mortality is evident from Table 4.45. On a direct level, health impacts are related to sanitation and hygiene. Health-related policies and implementation programmes in India focus predominantly on this aspect. Little attention is paid, however, to indirect effects, such as those resulting from high levels of pesticides and other chemicals that accumulate in food. Stress factors, for instance, are associated with high noise levels (Saksena 1998).

Rural dimension

Health problems caused by environmental pollution have rural and urban dimensions. In rural areas, factors that are affected by changes in the environment are land availability, forest cover, accumulation of agrochemicals in food, and indoor air pollution.

With the onset of land scarcity and depleting forest cover, poverty levels are heightened. This is accompanied by an increase in drudgery, as a result of having to go further in search of water, fuelwood, etc. The quality of drinking water is also not monitored and poses a great risk that involves diseases like amoebic and bacillary dysentery, cholera, diarrhoea, hepatitis, typhoid, and guinea worm. Scabies, leprosy, conjunctivitis, and trachoma can also be caused by impure water.

Indoor air pollution is of particular significance in rural areas. Among rural households, 90% use biofuels for cooking. These are inefficient polluting fuels such as firewood, dung, or crop residues. To add to this, cooking is usually done in small, ill-ventilated kitchens on inefficient traditional stoves. Pollutants from cooking stoves (for various fuel–stove combinations) are given in Table 4.46. The ranges of concentration of pollutants as have been measured in a few studies are given in Table 4.47.

The impacts fall into four major categories of ill health.

- Respiratory infections in young children
- Adverse pregnancy outcomes for women exposed during pregnancy
- Chronic lung diseases and associated heart disease in adults
- Cancer.

Urban dimension

The urban dimension of environmental health problems is manifested typically in slum areas. These areas suffer because of unequal access to land, public utilities, and urban infrastructure. Drainage and drinking and other water systems are in close contact, thus making them highly vulnerable to pollution. Slums are usually located in the proximity of major industries and road intersections, which has a very negative impact on the ambient air quality, etc. Thus, both indoor as well as ambient air quality leave a lot to be desired.

The MoEF has been conducting environmental epidemiological studies that aim to establish the health impacts of pollution. These studies are important because they can help to determine specific environmental changes, develop health indicators, etc. These sorts of impacts are hard to determine on a sound medical footing, and any studies carried out are very significant.

The only major epidemiological study of air pollution related illnesses was conducted in Mumbai. The health morbidity for cough, dyspnoea, common cold, eye irritation, headache, etc. showed a clear and strong relation to the profile of three pollutants—nitrogen dioxide, sulphur dioxide, and SPM. Lung functions were less efficient in the more polluted areas and respiratory symptoms increased with the increase in sulphur dioxide levels.

Significant achievements in the environmental sector since independence

Laws pertaining to the environment are growing in number. The past decade especially has seen a spate of environmental or environment-related laws. These vary from rules related to the storage and disposal, etc. of hazardous wastes (1989), chemicals (1989) and microorganisms (1989) to the National Environment Appellate Authority Ordinance (1997), which provides for the establishment of an authority to hear appeals regarding restriction of areas for industrial or other development activities. Thus, a more holistic view of environmental issues is developing.

The 73rd and 74th Constitutional Amendment Acts, both made in 1992, establish the devolution of powers to the panchayats and the urban local bodies, respectively. The amendments also influence the development of a decentralized structure for environmental management as well as for a more effective relationship between the environment and development, down to the local level. The National Conservation Strategy and Policy Statement on Environment and Development (1992) addresses this relationship directly.

The Policy Statement for Abatement of Pollution (1992) represents the change in the regulatory structure of the environment sector, which is gradually diversifying from a purely command-and-control *modus operandi* to market-based incentives. Depreciation allowances, exemption from excise or customs duty payment, and arrangement of soft loans for the adoption of clean technologies are instances of such incentives.

Another shift in approach that is evident is from a focus on the end-of-pipe treatment of pollution to a focus on cutting it out at the source, i.e. through clean technologies as well as housekeeping practices that maximize waste utilization and minimize its generation. However, to see this approach through, large financial investments and a considerable degree of institutional restructuring are called for. Environmental impact assessments have been made mandatory for 29 categories of development activities. This helps to highlight the possible short- and long-term environmental impacts of such activities at the very beginning, and also to lay out plans for their removal or mitigation. Table 4.02 contains a list of projects requiring environmental clearance.

A culture of environmental consciousness is spreading and drawing in more stakeholders. With an increase in the awareness of civil society, public interest litigation cases are on the rise and are also spurring judicial institutions into (pioneering) action. Implementation of the stringent norms for vehicular emissions has been brought about recently by the force of none other than the apex court of the country. The Supreme Court has also tried to encourage the high courts to take a more proactive stance.

References

Anderson. 1995

The conquest of smoke: legislation and pollution in colonial Calcutta

In *Nature Culture Imperialism: Essays on the Environmental History of South Asia,* edited by D Arnold and R Guha Delhi: Oxford University Press. 376 pp.

Bose R. 1999

Euro norms on new vehicles alone won't do much to check air pollution

Broadcast on All India Radio (New Delhi), 14 May 1999

CII. 1999

Environmental Legislation in India: A Guide for Industry and Business

New Delhi: Environment Management Division, Confederation of Indian Industry

CPCB. 1990
Status of Water Supply and Waste Water Collection, Treatment and Disposal in Class I Cities 1988
New Delhi: Central Pollution Control Board

CPCB. 1995a
Annual Report 1994I95
New Delhi: Central Pollution Control Board

CPCB. 1995b
Air pollution and its control
New Delhi: Central Pollution Control Board

CPCB. 1996
Annual Report 1995I96
New Delhi: Central Pollution Control Board

CPCB. 1997
Annual Report 1996I97
New Delhi: Central Pollution Control Board

CPCB. 1998
Pollution Control Acts, Rules and Notifications Issued Thereunder
New Delhi: Central Pollution Control Board

CPCB. 1999
Status of solid waste generation, collection, treatment and disposal in metro cities
New Delhi: Central Pollution Control Board

MoEF. 1993
Environment Action Programme
New Delhi: Ministry of Environment and Forests, Government of India

MoEF. 1997
Annual Report 1996I97
New Delhi: Ministry of Environment and Forests, Government of India.

MoEF. 1998
Annual Report 1997I98
New Delhi: Ministry of Environment and Forests, Government of India.

MoEF. 1999
Annual Report 1998I99
New Delhi: Ministry of Environment and Forests, Government of India.

MoEF. 2000
Draft paper on status of implementation of the Hazardous Wastes Rules, 1989
New Delhi: Ministry of Environment and Forests, Government India

Planning Commission. 1998
Executive Summary to the Ninth Five-Year Plan
New Delhi: Planning Commission, Government of India.

Saksena S. 1998
Human health and the environment
In *Proceedings of the National Workshop on Environment Statistics 1998*, 12–13 January 1998, Goa
New Delhi: Central Statistical Organization, Department of Statistics, Ministry of Programme Implementation and Planning, Government of India

TERI. 1999
Union Budget 1999I2000: energy and sustainable development
New Delhi: Tata Energy Research Institute

Thakur K. 1993
Environmental Protection Law and Policy in India
New Delhi: Deep and Deep Publications. 441 pp.

UNEP (United Nations Environment Programme). 1997
Asia-Pacific Environment Outlook
Thailand: UNEP

World Bank. 1996
India's Environment: taking stock of plans, programmes, and priorities
Washington, DC: World Bank. 317 pp.

Table 4.01 Environmental legislation, acts, rules, notifications, and amendments

General	The National Environment Appellate Authority Ordinance, 1997
	The Environmental Clearance Notification, 1994
	The Notification on Environmental Impact Assessment (EIA) of Development Projects, 1994
	The Environmental Standards Notification, 1993
	The Environmental Audit Notification, 1992
	National Conservation Strategy and Policy Statement on Environment and Development, 1992
	The National Environment Tribunal Bill, 1992
	Policy Statement on Abatement of Pollution, 1992
	The Public Liability Insurance Act, Rules, and Amendment, 1992
	The Public Liability Insurance Act, Rules, and Amendment, 1991
	The Environment (Protection) Act and Rules, 1986
Land	Involvement of Village Communities of Voluntary Agencies in Regeneration of Degraded Forests, 1990
	National Forest Policy, 1988
	The Industries (Development and Regulation) Act and Amendment, 1987
	The Coal Mines (Conservation and Development) Amendment Act, 1985
	The Model Regional and Town Planning and Development Law, 1985
	The Mines and Minerals (Regulation and Development) Act and Amendment, 1984
	The Forest (Conservation) Act, 1980
	The Urban Land (Ceiling and Regulation) Act, 1976
	The Mines and Minerals (Regulation and Development) Act and Amendment, 1957
	The Industries (Development and Regulation) Act and Amendment, 1951
	Provision in State Acts on Town and Country Planning
	Wildlife Protection Act
	Draft Notification on Fly Ash Utilization
Water	The Water (Prevention and Control of Pollution) Act, Rules, and Amendment, 1992
	The Coastal Regulation Zone Notification, 1991
	The Oil Fields (Regulation and Development) Act, 1984
	The Water (Prevention and Control of Pollution) Act, Rules, and Amendment, 1978
	The Water (Prevention and Control of Pollution) Act, Rules, and Amendment, 1977
	The Water (Prevention and Control of Pollution) Cess Act, 1977
	The Merchant Shipping Act, 1970
	The Indian Fisheries Act, 1897
Air	The Air (Prevention and Control of Pollution) Act, Rules, and Amendment, 1987
	The Factories Act and Amendment, 1987
	The Motor Vehicles (Amendment) Act, 1986
	The Air (Prevention and Control of Pollution) Act, Rules, and Amendment, 1983
	The Air (Prevention and Control of Pollution) Act, Rules, and Amendment, 1982
	The Atomic Energy Act, 1982
	The Air (Prevention and Control of Pollution) Act, Rules, and Amendment, 1981
	The Indian Boiler Act, 1923
	Notification on restriction of ash content of coal to be used in TPPs
Hazardous chemicals/wastes	Bio-medical Waste (Management and Handling) Rules, 1998
	Draft Hazardous (Management and Handling) Rules, 1997
	Manufacture, Use, Import and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells Rules (1989)
	The Hazardous Wastes (Management and Handling) Rules, 1989
	Manufacture, Storage, and Import of Hazardous Chemicals Rules, 1989

Source
Complied by TERI from various sources

Table 4.02 List of projects that require environmental clearance

Serial number	*Projects*
1	Nuclear power and related projects such as heavy water plants, nuclear fuel complexes, rare earth
2	River valley projects, including hydel power, major irrigation, and their combination including flood control
3	Ports, harbours, and airports (except minor ports and harbours)
4	Petroleum refineries including crude and product pipelines
5	Chemical fertilizers (nitrogenous and phosphatic other than single super phosphate)
6	Pesticides (technical)
7	Petrochemical complexes (both olefinic and aromatic) and petrochemical intermediates such as dimethyl and terephthalate, caprolactam, LAB, etc. and production of basic plastics such as low-density polyethylene, high-density polyethylene, polypropylene, polyvinychloride
8	Bulk drugs and pharmaceuticals
9	Exploration for oil and gas and their production, transportation, and storage
10	Synthetic rubber
11	Asbestos and asbestos products
12	Hydrocyanic acid and its derivatives
13	- Primary metallurgical industries (e.g., production of iron and steel, aluminium, copper, lead, and ferro alloys) - Electric arc furnaces (mini-steel plants)
14	Chlor-alkali industry
15	Integrated paint complexes including manufacture of resins and basic raw materials required in the manufacture of paints
16	Viscose staple fibre and filament yarn
17	Storage batteries integrated with manufacture of oxides of lead and lead antimony alloy
18	All tourism projects between 200 m and 500 m of high-tide line or at locations with an elevation of more than 100 m with investment of more than 50 million rupees
19	Thermal power plants
20	Mining projects (major minerals) with leases more than 5 ha
21	Highway projects
22	Tarred roads in Himalaya and/or forest areas
23	Distilleries
24	Raw skins and hides
25	Pulp, paper, and newsprint
26	Dyes
27	Cement
28	Foundries (individual)
29	Electroplating

Source

MoEF. 1994. **The Environmental Impact Assessment Notification**. New Delhi: Ministry of Environment and Forests.

Table 4.03 NAAQS (National ambient air quality standards) for India

Pollutant and time-weighted average	*Concentration in ambient air* (µg/m^3)			
	Industrial area	*Residential, rural, and other areas*	*Sensitive area*	*Methods of measurement*
Sulphur dioxide				
Annual average	80.0	60.00	15.00	Improved West and Gaeke method
24 hours	120.0	80.00	30.00	Ultraviolet fluorescence
Oxides of nitrogen				
Annual average	80.0	60 00	15.00	Jacob and Hochheiser modified (Na-Arsenite) method
24 hours	120.0	80.00	30.00	Gas-phase chemiluminescence
Suspended particulate matter				
Annual average	360.0	140.00	70.00	High-volume sampling (average flow rate not less than 1.1 m^3 per minute)
24 hours	500.0	200.00	100.00	
Respirable particulate matter (size less than 10 µm)				
Annual average	120.0	60.00	50.00	Respirable particulate matter sampler
24 hours	150.0	100.00	75.00	
Lead				
Annual average	1 0	0.75	0.50	Atomic absorption spectrometry after sampling using EPM 2000 or an equivalent filter paper
24 hours	1.5	1.00	0.75	
Carbon monoxide				
8 hours	5.0[a]	2.00[a]	1.00[a]	Non-dispersive infrared spectroscopy
1 hour	10.0[a]	4.00[a]	2.00[a]	
Ammonia				
Annual average	–	400.00[a]	–	–
24 hours	–	100.00[a]	–	–

[a] mg/m^3

Notes

1 Annual average is annual arithmetic mean of minimum 104 measurements in a year taken twice a week at 24-hourly intervals.

2 24-hourly and 8-hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

3 NAAQS, the levels of air quality necessary with an adequate margin of safety to protect public health, vegetation, and property.

4 Whenever and wherever two consecutive values exceed the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigations.

5 The state government / state board shall notify the sensitive and other areas in the respective states within a period of six months from the date of notification of NAAQS.

6 Standard for ammonia specified vide notification dated 14 October 1998. It does not mention either the type of areas for its specify applicability or the method of measurement.

Sources

1 CPCB. 1994. **Central Pollution Control Board Notification**. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests.

2 CII. 1999. ***Environmental Legislation in India. A Guide for Industry and Business***. New Delhi: Environment Management Division, Confederation of Indian Industry.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: general)]

Table 4.04 World Health Organization guideline values (μg/m³) for the classical air pollutants

Compound	*Annual ambient air concentration*	*Health end point*	*Observed effect level*	*Uncertainty factor*	*Guideline value*	*Average time*
Carbon monoxide	500-7000	Critical level of COHb <2.5%	–	–	10 000	15 minutes
					60 000	30 minutes
					30 000	1 hour
					10 000	8 hours
Lead	0.01-2	Critical level of Pb in blood <25 μg Pb/1	–	–	0.5	1 year
Nitrogen dioxide	10-150	Slight changes in lung function in asthmatics	365-565	0.5	200	1 hour
					40	1 year
Ozone	10-100	Respiratory function responses	–	–	120	8 hours
Sulphur dioxide	5-400	Changes in lung function in asthmatics	1000	2	500	10 minutes
		Exacerbations of respiratory	250	2	125	24 hours
		symptoms in sensitive individuals	100	2	50	1 year

Source
WHO. 1999. **Guidelines for Air Quality.** Geneva: World Health Organization (http://www.who.int)

Table 4.05 Noise standards

		Limits in dB(A)	
		Daytime	*Night-time*
Area code	*Category of area*	*(6 a.m. to 9 p.m.)*	*(9 p.m. to 6 a.m.)*
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D[a]	Silence zone	50	40

[a] areas up to 100 m around premises such as hospitals, educational institutions, and courts

Note
The silence zones are to be declared by the competent authority. Use of vehicular horns and loudspeakers, and bursting of crackers are banned in these zones.

Source
CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 313. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (noise)]

Table 4.06 Criteria for classification of inland surface water

Parameter	*Maximum/ minimum*	*Drinking water without conventional treatment but after disinfection*	*Outdoor bathing, organized*	*Drinking water with conventional treatment followed by disinfection*	*Propagation of wildlife and fisheries*	*Irrigation, industrial cooling, etc.*
Dissolved oxygen (mg/litre)	Minimum	6	5	4	4	–
Biological oxygen demand (mg/litre)	Minimum	2	3	3	–	–
Total coliform bacteria (most probable number per 100 millilitres)	Maximum	50	500	5000	–	–
Total dissolved solids (mg/litre)	Maximum	500	–	1500	–	2100
Chloride as chlorine (mg/litre)	Maximum	250	–	600	–	500
Colour (hazen)	Maximum	10	300	300	–	–
Sodium absorption ratio	Maximum	–	–	–	–	26
Boron (mg/litre)	Maximum	–	–	–	–	2
Sulphates (mg/litre)	Maximum	400	–	400	–	1000
Nitrates (mg/litre)	Maximum	20	–	50	–	–
Free ammonia as nitrogen (mg/litre)	Maximum	–	–	–	12	–
Conductivity at 25 °C (µs/cm)	Maximum	–	–	–	1.00	2.25
pH	–	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.0-8.0
Arsenic (mg/litre)	Maximum	0.05	0.20	0.20	–	–
Iron (mg/litre)	Maximum	0.3	–	50	–	–
Fluorides (mg/litre)	Maximum	1.5	1.5	1.0	–	–
Lead (mg/litre)	Maximum	0.1	–	0.1	–	–
Copper (mg/litre)	Maximum	1.5	–	1.5	–	–
Zinc (mg/litre)	Maximum	15	–	15	–	–

Source

ISI. 1982. **Indian Standards** (IS: 2291). New Delhi: Indian Standards Institution.

Table 4.07 Maximum permissible limits (mg/litre) for industrial effluent discharges

Parameter	*Into inland surface waters Indian Standards: 2490 (1974)*	*Into public sewers Indian Standards: 3306 (1974)*	*On land for irrigation Indian Standards: 3307 (1974)*
pH	5.5-9.0	5.5-9.0	5.5-9.0
Biological oxygen demand (for 5 days at 20 °C)	30	350	100
Chemical oxygen demand	250	–	–
Suspended solids	100	600	200
Total dissolved solids (inorganic)	2100	2100	2100
Temperature (°C)	40	45	–
Oil and grease	10	20	10
Phenolic compounds	1	5	–
Cyanides	0.2	2	0.2
Sulphides	2	–	–
Fluorides	2	15	–
Total residual chlorine	1	–	–
Pesticides	–	–	–
Arsenic	0.2	0.2	0.2
Cadmium	2	1	–
Chromium (hexavalent)	0.1	2.0	–
Copper	3	3	–
Lead	0.1	1.0	–
Mercury	0.01	0.01	–
Nickel	3	3	–
Selenium	0.05	0.05	–
Zinc	5	15	–
Chlorides	1000	1000	600
Boron	2	2	2
Sulphates	1000	1000	1000
Sodium (%)	–	60	60
Ammoniacal nitrogen	50	50	–
Radioactive materials			
Alpha emitters (milli curie/millilitre)	10^{-7}	10^{-7}	10^{-8}
Beta emitters (μ curie/millilitre)	10^{-6}	10^{-6}	10^{-7}

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. pp. 311-312. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 4.08 Effluent standards for integrated iron and steel plants

Parameter	*Permissible limit* (mg/litre)
Coke oven	
By-product plant	–
pH	6.0–8.0
Suspended solids	100.0
Phenol	1.0
Cyanide	0.2
Biological oxygen demand (5 days at 20 °C)	30.0
Chemical oxygen demand	250.0
Ammoniacal nitrogen	50.0
Oil and grease	10.0
Other plants such as sintering plant, blast furnace, steel melting, and rolling mill	
pH	6.0–9.0
Suspended solids	100.0
Oil and grease	10.0

Source
CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. pp. 281–282.
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 4.09 Effluent standards for Al (aluminium) industry

Plant	*Parameter*	*Permissible limit*
Alumina plant		
Raw material handling	Primary and secondary crusher particulate matter	150 mg/m³
Precipitation area: calcination	Particulate matter	250 mg/m³
	Carbon monoxide	1% maximum
	Stack height[a]	
Smelter plant		
Green anode shop	Particulate matter	150 mg/m³
Anode bake oven	Particulate matter	150 mg/m³
	Total fluoride	0.3 kg/tonne of Al
Potroom	Particulate matter	150 mg/m³
	Total fluoride	
	Vertical stud soderberg	4.7 kg/tonne of Al produced
Horizontal stud soderberg	6.0 kg/tonne of Al produced	
	Prebacked side worked	2.5 kg/tonne of Al produced
	Prebacked centre worked	1.0 kg/tonne of Al produced
	Stack height[a]	

[a] $H = 14\,Q^{0.3}$, where Q is the emission rate of sulphur dioxide in kg/h and H is the stack height in metres.

Source
CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. pp. 284–285.
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 4.10 Effluent standards for sugar industry

Parameter	*Permissible limit* (mg/litre) *Disposal on land*	 *Disposal in surface water*
Biological oxygen demand (5 days at 20 °C)	100	30
Suspended solids	100	30

Source
CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 267.
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 4.11 Effluent standards for large pulp and paper industries

Capacity (tonnes a year)	*Parameter*	*Permissible limit*
Above 24,000	pH	7.0–8.5
	Biological oxygen demand at 20 °C	30 mg/litre
	Chemical oxygen demand	350 mg/litre
	Suspended solids	50 mg/litre
	Total organic chloride	2.0 kg/tonne of paper produced
	Flow (total waste water discharge)	–
	Large pulp and paper[a]	200 m³/tonne of paper produced
	Large rayon grade newsprint	150 m³/tonne of paper produced

[a] the standards with respect to total waste water discharge for large pulp and paper mills established from 1992 will meet the standards of 100 m³/tonne of paper produced

Source
CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 296.
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 4.12 Effluent standards (mg/litre, except for pH) for oil refinery industry

Parameter	*Permissible limit*	*Quantum* (kg/thousand tonnes of crude processed)
Oil and grease	10.0	7.00
Phenol	1.0	0.70
Sulphide	0.5	0.35
Biological oxygen demand (5 days at 20 °C)	15.0	10.50
Suspended solids	20.0	14.00
pH	–	6.00–8.50

Source
CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 266.
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (water: general)]

Table 4.13 Effluent standards (mg/litre, except for pH) for petrochemical (basic and intermediates) industry

Parameter	*Permissible limit*
pH	6.5-8.5
Biological oxygen demand (5 days at 20 °C)[a]	50.0
Phenol[b]	5.0
Sulphide (as S)	2.0
Chemical oxygen demand	250.0
Cyanide (as CN)	0.2
Fluoride (as F)[c]	15.0
Total suspended solids	1000.0
Hexavalent chromium	0.1
Total chromium (as Cr)[d]	2.0

[a] the state board may prescribe the biological oxygen demand value of 30 mg/litre if the recipient system so demands.

[b] the limit for phenol shall be confirmed at the outlet of effluent treatment of phenol plant. However, at the final disposal point, the limit shall be less than 1 mg/litre.

[c] the limit for fluoride shall be confirmed at the outlet of the chrome removal unit. However, at the disposal point, fluoride concentration shall be lower than 5 mg/litre.

[d] the limits for total and hexavalent chromium shall be confirmed at the outlet of the chromate removal. This implies that in the final treated effluent, total and hexavalent chromium shall be lower than prescribed herein.

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder**. Volume I. p. 286.
New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 4.14 Effluent standards for thermal power plants

Discharges from	*Parameter*	*Maximum limiting concentration* (mg/litre) *(except for pH and temperature)*
Condenser cooling waters (once through the cooling system)	pH	6.5–8.5
	Temperature	Not more than 5 °C than the intake water temperature
	Free available chlorine	0.5
Boiler blow-downs	Suspended solids	100
	Oil and grease	20
	Copper (total)	1
	Iron (total)	1
Cooling tower blow-downs	Free available chlorine	0.5
	Zinc	1.0
	Chromium (total)	0.2
	Phosphate	5.0
	Other corrosion inhibiting material	Limit to be established on a case-by-case basis by the central board in case of union territories and state board in case of states
Ash pond effluent	pH	6.5–8.5
	Suspended solids	100
	Oil and grease	20

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder**. Volume I. p. 267. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: power)]

Table 4.15 Maximum permissible limits (mg/m^3) for emissions of particulate matter from thermal power stations

Boiler size	*Protected areas*	*Other areas*
Less than 210 MW	150	350
210 MW or more	150	150

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 280. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: power)]

Table 4.16 Guidelines for minimum stack heights

Power generation capacity	*Stack height* (m)
Less than 200/210 MW	–[a]
200/210 and above to less than 500 MW	220
500 MW and above	275
Steam-generating capacities of boilers (tonnes per hour)	
less than 2	–[b]
between 2 and 5	12
between 5 and 10	15
more than 10	18
between 15 and 20	21
between 20 and 25	24
between 25 and 30	27
more than 30	–[a]

[a] using formula $H = 14\,Q^{0.3}$, whichever is more, where Q is the emission rate of sulphur dioxide in kg/h and H is the stack height

[b] 2.5 times the height of the neighbouring building or 9 m, whichever is more

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 283. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 4.17 Indian emission standards and proposed World Bank emission guidelines for thermal power plants

	Indian emission standards			*World Bank proposed emission guidelines*		
Parameters	*Capacity*	*Fuels*	*Standards*	*Standards (mg/m³)*	*Control options*	*Main concerns*
Particulate matter	Less than 200/210 MW	–	350 mg/Nm³	50	Existing technologies (ESP or bag houses) to achieve emission below 50 mg/m³	Fine particulate: PM_{10} and $PM_{2.5}$
	200/210 MW and above	–	150 mg/Nm³	If it is not achievable, 99.9% removal efficiency for all the plants in airsheds with good air quality	Coal cleaning to reduce mass loadings and improve boiler efficiency and reduce boiler maintenance	–
Sulphur dioxide	Less than 200 MW	–	H - 14 $(Q)^{0.8}$ metres, Q-emission rate of sulphur dioxide in kg/h	2000 Maximum level 0.2 TPD per MW up to 500 MW plus	Use of gas or low sulphur fuels Furnace sorbent injection (30%-60% removal)	Local impacts of sulphur dioxide and sulphates on health Long-range transport acidification and visibility
	200 MW and less than 500 MW	–	220 m stack height	0.1 TPD per MW for each additional MW over 500 MW	Dust injection, dry or wet scrubbers (up to 95% removal), or fluidized bed combustion (up to 95% removal)	–
	500 MW and above	–	275 m stack height	But not more than 500 TPD for any plant	–	–
Oxides of nitrogen	All existing units	Natural gas/ Naphtha	150 at 15% excess oxygen	750 (365 PPM) (coal)	Low oxides of nitrogen burners with or without other combustion modifications	Contribution to creation of ground level ozone, acidification and visibility impacts
				460 (225 PPM) (oil)	Reburning, water/steam injection	
	New units (effective from 1 January 1998)			320 (155 PPM) (gas)	Selective catalytic or non catalytic reduction	
	400 MW and above	Natural gas	50			
		Naphtha	100			
	100-400 MW	Natural gas	75			
		Naphtha	100			
	<100 MW	Natural gas	100			
		Naphtha				

PPM - parts per million; TPD - tonnes per day

Note
The range of control of sulphur dioxide is greater because of large differences in the sulphur content of different fuels and in control costs. In general, for low sulphur (<1% S), high calorific fuels, specific control may not be required. Coal cleaning (when feasible), sorbent injection or fluidized bed combustion may be adequate for medium sulphur fuels (1-3% S). FGD may be considered for high sulphur fuels (>3% S). The technology choice depends on a benefit-cost analysis of the environmental performance for different fuels and the cost of controls.

Sources
1 Data obtained from the Ministry of Environment and Forests, Government of India, New Delhi.
2 TERI. 1998 **Review of the environmental guidelines prepared by the World Bank for new thermal power plants.** Final report submitted to the World Bank. New Delhi: Tata Energy Research Institute.

Table 4.18 Maximum permissible limits (mg/m³) for emissions from integrated iron and steel plants

Pollutants and sources	*Emission limit*
Particulate matter	
Sintering plant	150
Coke oven	50
Steel making	–
During normal operation	150
During oxygen lancing	400
Carbon monoxide	
Coke oven (kg per tonne of coke produced)	3

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder**. Volume I. p. 279. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 4.19 Maximum permissible limits (mg/m³) for emissions of particulate matter from cement plants

	Maximum permissible limits (mg/m³)	
Capacity	*Protected areas*	*Other areas*
200 TPD	250	400
Greater than 200 TPD	150	250

TPD - tonnes per day

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder**. Volume I. p. 270. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 4.20 Maximum permissible limits (mg/m³) for emissions from fertilizer plants

Product	*Pollutant*	*Emission limit*
Urea		
Pricing tower	Particulates	50
Phosphatic fertilizer		
Acidification of rock phosphate	Fluorides	25
Granulation, mixing, and grinding of rock phosphate	Particulates	150

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 278. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 4.21 Maximum permissible limits (**kg per tonne of feed**[a]) for emissions of sulphur dioxide from oil refineries

Process	*Emission limit*
Atmospheric and vacuum distillation	0.25
Catalytic cracker	2.50
Sulphur recovery unit	120.00

[a] indicates the feed for the specific part of the process under consideration.

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 284. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: refineries)]

Table 4.22 Maximum permissible limits (mg/m³) for emissions of particulate matter from calcium carbide plants

Source	*Emission limit*
Kiln	250
Arc furnace	150

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 278. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 4.23 Maximum permissible limits for emissions from copper, lead, and zinc smelting units

Pollutant	*Source*	*Emission limit*
Particulate matter	Concentrator	150 mg/m^3
Oxides of sulphur[a]	Smelter and converter	4 kg per tonne of concentrated (100%) acid produced

[a] off-gases must be utilized for sulphuric acid manufacturing

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 279. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 4.24 Maximum permissible limits (mg/m^3) for emissions of particulates from carbon black industry

Pollutant	*Emission limit*
Particulate matter	150

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 279. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE + [Section: Environment (air: industry)]

Table 4.25 Maximum permissible limits (mg/m^3) for emissions of particulate matter from aluminium industry

Process	*Emission limit*
Calcination	250
Smelting	150

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 278. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: industry)]

Table 4.26 Emission factors (g/km) for different vehicles

Vehicle	*Carbon monoxide*	*Hydrocarbons*	*Oxides of nitrogen*	*Sulphur dioxide*	*Lead*	*Total suspended particulate matter*
Two-wheeler	8.30	5.18	0.10	0.05	0.05	0.05
Car (petrol)	2.60[a]	6.20–0.30	2.70–0.60	0.22–0.14	0.01	0.33–0.08
Three-wheeler	12.25	7.65	0.10	0.10	0.01	0.50
Car (diesel)	1.10	0.28	1.40	0.93	–	0.60
Bus	12.70	2.10	21.00	2.50	–	2.00
Truck	12.70	2.10	21.00	2.50	–	2.00
Light commercial vehicle	5.39	0.66	9.34	0.90	–	0.83

[a] new cars with catalytic converters; 28.90 g/km for pre-1984 model cars

Source

IIP. 1985. ***State of Art Report on Vehicle Emissions.*** Dehra Dun: Indian Institute of Petroleum.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: transport)]

Table 4.27 Emission limits (%) for petrol-driven vehicles (idling condition)

Parameter	*Type of vehicle*	*Limit* (% by volume)
Carbon monoxide	Four-wheelers	3.0
	Two- and three-wheelers	4.5

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 314. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 4.28 Emission limits for diesel vehicles

Method of test	*Light absorption coefficient* (millilitre)	*Maximum smoke density*	
		Bosch units	*Hartridge units*
Full load at a speed of 60%–70% of maximum engine-rated speed specified by the manufacturer	3.1	5.2	75
Free acceleration	2.3	–	65

Source

CPCB. 1998. **Pollution Control Acts, Rules, and Notifications issued thereunder.** Volume I. p. 314. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. 501 pp.

Table 4.29 Mass emission standards (g/km) for petrol-driven vehicles

		1 April 1996		*1 April 2000*	*1 April 2005*
	1 April 1991	*Without catalytic converter*	*With catalytic converter*	*Euro I Norm*	*Euro II Norm*
Four-wheelers – passenger vehicle					
Carbon monoxide	14.3-27.1	8.68-12.40	4.34-6.20	2.72	2.2
Hydrocarbon	2.0-2.9	–	–	–	–
Hydrocarbon and oxides of nitrogen	–	3.00-4.36	1.50-2.18	0.97	0.5

		1 April 1996	*1 April 1998*	*1 April 2000*
	1 April 1991	*Indian driving cycle with warm start*	*Indian driving cycle with cold start*	*Indian driving cycle with cold start*
Two-wheelers				
Carbon monoxide	12-30	4.5	4.5	2
Hydrocarbon	8-12	–	–	–
Hydrocarbon and oxides of nitrogen	–	3.6	3.6	2

		1 April 1996	*1 April 1998*	*1 April 2000*
	1 April 1991	*Indian driving cycle with warm start*	*Indian driving cycle with cold start*	*Indian driving cycle with cold start*
Three-wheelers				
Carbon monoxide	12-30	6.75	6.75	4
Hydrocarbon	8-12	–	–	–
Hydrocarbon and oxides of nitrogen	–	5.40	5.40	2

Source

AIAM. 1999. ***Fuel and Vehicular Technology.*** New Delhi: Association of Indian Automobile Manufacturers.

Table 4.30 Mass emission standards (g/kWh) for diesel-driven vehicles

	1 April 1992	*1 April 1996*	*1 April 2000*	*Euro II*	*Euro III*
Gross vehicle weight >3.5 tonnes					
Carbon monoxide	14.0	11.2	4.50	4.00	2.0
Hydrocarbon	3.5	2.4	1.10	1.10	0.6
Oxides of nitrogen	18.0	14.4	8.00	7.00	5.0
Particulate matter for >85 kW	0	0	0.36	0.15	0.1
Particulate matter for <85 kW	0	0	0.61	0.15	0.1

	1 April 1992 (g/kWh)	*1 April 1996* (g/km)	*1 April 2000* (g/km)
Gross vehicle weight < 3.5 tonnes			
Carbon monoxide	14.0	5.0-9.0	2.72-6.90
Hydrocarbon	3.5	–	–
Oxides of nitrogen	18.0	2.0-4.0	0.97-1.70
Particulate matter	0.0	–	0.14-0.25

Source

AIAM. 1999. *Fuel and Vehicular Technology.* New Delhi: Association of Indian Automobile Manufacturers.

Table 4.31 Categories of biomedical waste

Option	*Waste category*	*Treatment and disposal*
Category no. 1	**Human anatomical waste**	Incineration[a] Deep burial[b]
Category no. 2	**Animal waste** (animal tissues, organs, body parts, carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals, colleges, discharge from hospitals, animal houses)	Incineration[a] Deep burial[b]
Category no. 3	**Microbiology and biotechnology waste** (wastes from laboratory cultures, stocks or specimens of micro-organisms, live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures)	Local autoclaving/micro-waving/ incineration[a]
Category no. 4	**Waste sharps** (needles, syringes, scalpels, blades, glass etc. that may cause puncture and cuts. This includes both used and unused sharps.)	Disinfection (chemical treatment,[c] Autoclaving/micro-waving and mutilation/shredding[d]
Category no. 5	**Discarded medicines and cytotoxic drugs** (wastes comprising outdated, contaminated and discarded medicines)	Incineration/destruction and drugs[a] Disposal in secured landfills
Category no. 6	**Solid waste** (items contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, linens, beddings, other material contaminated with blood)	Incineration[a]/autoclaving/ microwaving
Category no. 7	**Solid waste** (waste generated from disposal items other than waste sharps such as tubings, catheters, intravenous sets, etc.)	Disinfection by chemical treatment[c] autoclaving/microwaving and mutilation/shredding[d]
Category no. 8	**Liquid waste** (waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities)	Disinfection by chemical treatment[c] and discharge into drains
Category no. 9	**Incineration ash** (ash from incineration of any biomedical waste)	Disposal in municipal landfill
Category no. 10	**Chemical waste** (chemicals used in production of biologicals, chemicals used in disinfection, as insecticides, etc.)	Chemical treatment and discharge[c] into drains for liquids and secured landfill for solids

[a] there will be no chemical pretreatment before incineration. Chlorinated plastics shall not be incinerated.

[b] deep burial shall be an option available only in towns with population less than half a million and in rural areas.

[c] chemical treatment using at least one per cent hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfection.

[d] mutilation/shredding must be such that it prevents unauthorized reuse.

Source

CPCB. 2000. ***Manual on Hospital Wastage Management***. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests.

Table 4.32 Ambient air quality levels in highly polluted cities ($\mu g/m^3$): 1998

	Sulphur dioxide		*Oxides of nitrogen*		*Suspended particulate matter*	
State / Union Territory	*Industrial*	*Residential*	*Industrial*	*Residential*	*Industrial*	*Residential*
Andhra Pradesh						
Hyderabad	38.9	31.8	84.9	100.0	776	564
Visakhapatnam	11.4	27.0	16.6	34.8	113	332
Bihar						
Dhanbad	–	65.6	–	57.5	–	238
Jamshedpur	74.1	–	93.9	–	365	–
Jharia	76.4	–	53.7	–	454	–
Patna	–	34.1	–	41.0	–	717
Sindri	64.5	–	58.4	–	177	–
Delhi	85.8	84.8	164.1	112.6	1878	1531
Goa						
Ponda	–	9.8	–	18.3	–	166
Vasco	8.6	–	17.8	–	103	–
Himachal Pradesh						
Damtal	–	5.8	–	21.5	–	301
Parwanoo	–	1.4	10.3	12.9	118	302
Shimla	–	3.6	–	13.6	–	127
Haryana						
Faridabad	35.7	–	13.3	–	386	–
Yamuna Nagar	32.2	–	23.1	–	232	–
Karnataka						
Bangalore	40.0	21.0	44.0	31.0	259	199
Mysore	72.0	–	64.0	–	209	–
Kerala						
Kochi	34.1	22.3	21.4	27.1	804	183
Thiruvananthapuram	25.8	14.8	19.1	44.1	179	299
Kottayam	1.7	–	24.1	–	55	–
Kozhikode	2.3	2.5	7.3	6.6	75	73
Maharashtra						
Mumbai	21.7	32.2	24.9	59.8	226	475
Nagpur	16.5	25.6	27.5	76.0	278	668
Pune	100.4	48.1	119.2	56.6	748	247
Madhya Pradesh						
Bhilai	31.4	29.6	34.9	63.2	379	226
Bhopal	17.5	34.4	26.3	52.3	384	574

Continued

Table 4.32 continued

State / Union Territory	Sulphur dioxide Industrial	Sulphur dioxide Residential	Oxides of nitrogen Industrial	Oxides of nitrogen Residential	Suspended particulate matter Industrial	Suspended particulate matter Residential
Indore	16.3	26.2	15.3	27.3	382	612
Jabalpur	–	–	–	12.8	–	153
Korba	–	30.2	–	41.1	–	272
Nagda	55.2	84.0	24.6	67.9	141	335
Raipur	9.9	8.8	35.3	29.2	273	268
Satna	11.7	10.8	14.5	13.0	269	198
Orissa						
Angul	–	17.6	–	19.5	–	254
Rourkela	35.5	32.0	27.6	36.1	154	192
Punjab						
Jalandhar	–	–	–	–	–	–
Ludhiana	–	–	–	–	–	–
Rajasthan						
Alwar	28.7	13.5	156.6	75.2	208	699
Jaipur	26.6	33.8	45.6	83.6	495	837
Kota	10.2	9.7	26.2	25.3	300	274
Tamil Nadu						
Coimbatore	13.4	11.0	20.7	29.6	150	220
Chennai	31.3	31.5	38.8	44.6	288	348
Tuticorin	32.7	11.0	27.8	12.6	98	124
Uttar Pradesh						
Agra	24.8	10.0	20.9	8.9	818	482
Anpara	117.0	–	121.7	–	513	–
Dehra Dun	17.2	15.8	14.5	14.3	301	307
Gajroula	19.7	15.5	–	–	301	247
Kanpur	35.4	66.0	51.7	87.1	882	1617
Lucknow	32.5	60.0	34.4	64.2	524	895
West Bengal						
Haldia	87.8	–	115.4	–	395	–
Howrah	–	–	–	–	–	–
Chandigarh	5.8	4.8	9.8	9.0	331	229
Pondicherry	–	–	–	–	–	–

Source
CPCB. 2000. **National Ambient Air Quality Monitoring Series.** New Delhi: Central Pollution Control Board, Ministry of Environment and Forests. [NAAQMS/15/2000-01].

Table 4.33 Average noise levels (dB[A]) in various metropolitan cities

Metropolitan cities	*Industrial area*	*Commercial area*	*Residential area*	*Silence area*
Kolkata				
Day	78	82	79	79
Night	67	75	65	65
Mumbai				
Day	76	75	70	66
Night	65	66	62	52
Chennai				
Day	71	78	66	63
Night	66	71	48	49
Bangalore				
Day	78	76	67	67
Night	53	57	50	–

Source
MoEF. 1995. ***State of the Environment.*** New Delhi: Ministry of Environment and Forests.

Table 4.34 Pollution control status of 17 categories of industries (**no. of units**): 31 December 2000

			Status	
Industry	*Total*	*Closed*	*Having adequate facilities to comply with the standards*	*Not having adequate facilities to comply with the standards*
Aluminium	7	1	6	–
Caustic soda	25	–	25	–
Cement	116	8	108	–
Copper	2	–	1	1
Distillery	177	32	134	11
Dyes and dye intermediates	64	8	56	0
Fertilizer	110	10	97	3
Iron and steel	8	–	2	6
Leather	70	11	59	–
Pesticides	71	7	63	1
Petrochemicals	49	–	49	–
Pharmaceuticals	251	26	225	–
Pulp and paper	96	20	75	1
Refinery	12	–	12	0
Sugar	392	47	334	11
Thermal power plants	97	2	76	19
Zinc	4	–	4	–
Total	1551	172	1326	53

Source
http://164.100.32.5/17cat/17cat.html

Table 4.35 Summary status of pollution contract in 17 categories of industries in states and union territories (**no. of units**): 31 December 2000

			Status	
State / Union Territory	*Total*	*Closed*	*Having adequate facilities to comply with the standards*	*Not having adequate facilities to comply with the standards*
State				
Andhra Pradesh	173	29	142	2
Assam	15	2	11	2
Bihar	62	21	35	6
Delhi	5	1	4	0
Goa	6	–	6	–
Gujarat	177	7	168	2
Haryana	43	5	37	1
Himachal Pradesh	9	–	9	–
Jammu and Kashmir	8	3	5	–
Karnataka	85	9	72	4
Kerala	28	6	20	2
Madhya Pradesh	78	11	60	7
Maharashtra	335	24	302	9
Meghalaya	1	–	1	0
Orissa	23	1	15	7
Punjab	45	6	39	0
Rajasthan	49	6	43	0
Sikkim	1	–	1	0
Tamil Nadu	119	2	117	0
Uttar Pradesh	224	21	198	5
West Bengal	58	17	35	6
Union Territory				
Chandigarh	1	–	1	0
Pondicherry	6	1	5	0
Total	1551	172	1326	53

Source
http://164.100.32.5/17cat/17cat.html

Table 4.36 List of polluted river stretches in India

River	*Polluted stretch*	*Desired*	*Existing class*	*Critical parameters*	*Possible sources of pollution*
Sabarmati	Immediate upstream of Ahmedabad	B	E	Dissolved oxygen, BOD, coliforms	Domestic and industrial waste from Ahmedabad
	Sabarmati Ashram to Vautha	D	E	Dissolved oxygen, BOD, coliforms	Domestic and industrial waste from Ahmedabad
Subernarekha	Hatia Dam to Baharagora	C	Partly D and partly E	Dissolved oxygen, BOD, coliforms	Domestic and industrial waste from Ranchi and Jamshedpur
Godavari	Downstream of Nasik to Nanded	C	Partly D and partly E	BOD	Waste from sugar, distillery, and food-processing industries
	City limit to Nasik and Nanded	B	Partly D and partly E	BOD	Waste from sugar, distillery, and food-processing industries
Krishna	Karad to Sangli	C	Partly D and partly E	BOD	Waste from sugar and distillery industries
Indus (tributaries, Sutlej)	Downstream of Ludhiana to Harike	C	Partly D and partly E	Dissolved oxygen, BOD	Industrial waste from hosieries, tanneries, electroplating, and engineering
	Downstream of Nangal to Anandpur	C	E	Ammonia	Wastes of fertilizer, chlor alkali, and paper mills from Nangal
Ganga (tributaries)					
Yamuna	Delhi to confluence with Chambal	C	Partly D and partly E	Dissolved oxygen, BOD, coliforms	Domestic and industrial waste from Delhi, Mathura, and Agra
	In the city limits of Delhi, Mathura	B	Partly D and partly E	Dissolved oxygen, BOD, coliforms	Domestic and industrial waste from Delhi, Mathura, and Agra
Hindon	Saharanpur to confluence with Yamuna	D	E	Dissolved oxygen, BOD, coliforms	Industrial and domestic waste from Saharanpur and Ghaziabad
Chambal	Downstream of Nagda and downstream of Kota	C	Partly D and partly E	BOD, dissolved oxygen	Domestic and industrial waste from Nagda and Kota
Damodar	Downstream of Dhanbad to Haldia	C	Partly D and partly E	BOD, toxic	Industrial waste from Dhanbad, Durgapur, Asansol, Haldia, and Burnpur
Gomti	Lucknow to confluence with Ganga	C	Partly D and partly E	Dissolved oxygen, BOD, coliforms	Industrial waste from distilleries and domestic waste from Lucknow
Kali	Downstream of Modinagar to confluence with Ganga	C	Partly D and partly E	BOD, coliforms	Industrial and domestic waste from Modinagar

B: outdoor bathing, organized
C: drinking water source with conventional treatment followed by disinfection
D: propagation of wildlife and fisheries
E: irrigation, industrial cooling, etc.
BOD biological oxygen demand

Source
MoEF. 1993. ***National Environment Programme***. p.167 New Delhi Ministry of Environment and Forests. 220 pp.

Table 4.37 GPIs (Grossly polluting industries) discharging into water courses in states and union territories

State / Union Territory	*Number of GPIs*
State	
Andhra Pradesh	64
Assam	12
Bihar	68
Goa	1
Gujarat	19
Haryana	128
Himachal Pradesh	51
Jammu and Kashmir	–
Karnataka	5
Kerala	12
Madhya Pradesh	16
Maharashtra	–
Nagaland	–
Orissa	25
Punjab	20
Rajasthan	14
Tamil Nadu	714
Delhi	7
Uttar Pradesh	372
West Bengal	–
Union Territory	
Andaman and Nicobar Islands	–
Daman and Diu, Dadra and Nagar Haveli	–
Lakshadweep	–
Pondicherry	4
Total	1532

Note
There are no GPIs discharging into water courses in Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Sikkim, Tripura, and Chandigarh.

Source
CPCB. 1997. ***Annual Report 1996/97***. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests.

Table 4.38 Potable water quality standards as recommended by the WHO (mg/litre)

Parameter	*Class A: maximum permissible limit*	*Class B: maximum allowable limit*	*Indian Standards: 10 500 (1991)*
Physical parameters			
Colour (hazen)	5	25	5
Turbidity (NTU)	5	25	5
pH	7.0–8.5	6.5–9.2	6.5–8.5
Temperature (°C)	–	–	–
Conductivity (μ/cm)	–	–	–
Total dissolved solids	–	–	–
Total suspended solids	–	–	–
Total solids	500	1500	500
Chemical parameters			
Total hardness	–	–	300
Calcium as calcium carbonate	175	500	75
Magnesium as calcium carbonate	215	650	30
Acidity	–	–	–
Alkalinity as calcium carbonate	–	–	200
Bicarbonate as calcium carbonate	–	–	–
Carbonate as calcium carbonate	–	–	–
Hydroxide as calcium carbonate	–	–	–
Chlorides as chlorine	–	–	250
Total residual chlorine	–	–	–
Sulphates	200	400	200
Fluorides	0.5	1.0–1.5	1
Phenol	0	0	0
Manganese	0.1	0.5	0.1
Silica	–	–	–
Sodium	–	–	–
Potassium	–	–	–
Organic and nutrient parameters			
Dissolved oxygen	–	–	–
Biological oxygen demand	–	–	–
Chemical oxygen demand	–	–	–
Phosphates	–	–	–
Mercury	–	–	–
Oil and grease	–	–	–
Ammoniacal nitrogen	–	–	–
Nitrates	–	50–100	45
Nitrites	–	–	–
Heavy metals			
Iron	0.3	1	0.3
Chromium	–	0.1	0.1
Boron	–	–	1
Zinc	–	–	5
Copper	1	1.5	1.5
Lead	–	0.1	0.1

Sources

1 WHO. 1986. ***WHO Handbook***. Geneva: World Health Organization.

2 ISI. 1991. **Indian Standards (IS: 10 500)**. New Delhi: Indian Standards Institution.

Table 4.39 Municipal solid waste generation (**kg per capita per day**) in cities

City	*1971-73*	*1986/87*	*1994*
Ahmedabad	0.24	–	0.59
Ajmer	0.24	0.44	–
Allahabad	0.20	0.50	–
Aurangabad	0.42	0.67	–
Bangalore	0.32	–	0.48
Baroda	0.29	–	0.39
Bhopal	0.26	–	0.51
Bikaner	0.29	–	–
Chandigarh	0.36	–	–
Chennai	0.32	–	0.66
Coimbatore	0.31	–	0.43
Delhi	0.21	–	0.48
Gorakhpur	0.21	0.64	–
Guwahati	0.24	–	–
Gwalior	0.27	–	–
Howrah	0.59	–	–
Hyderabad	0.33	–	0.40
Jabalpur	0.30	–	0
Jaipur	0.28	–	0.40
Jodhpur	0.20	0.45	–
Kanpur	0.55	–	0.64
Kochi	–	0.27	0.52
Kolkata	0.50	–	0.34
Kota	0.25	0.40	–
Kozhikode	0.15	0.16	–
Kurnool	0.20	–	–
Lucknow	–	–	0.62
Ludhiana	–	0.40	0.40
Madurai	0.38	–	0.39
Mumbai	0.49	–	0.44
Nagpur	0.22	–	0.27
Patna	0.48	–	0.36
Pune	0.24	–	0.31
Raipur	0.32	0.23	–
Rajkot	0.07	0.21	–
Sangli	0.23	0.30	–
Surat	0.15	–	0.60
Tatanagar	0.45	–	–
Thane	0.23	–	–
Tiruchirapalli	0.21	–	–
Thiruvananthapuram	0.12	0.34	–
Udaipur	0.14	–	–
Vadodara	–	–	0.39
Varanasi	–	–	0.40
Vijayawada	0.17	0.44	–
Visakhapatnam	–	0.31	0.40

Sources

1 INSDOC. 1983. ***Solid Waste Management in Developing Countries***. New Delhi: Indian National Scientific Documentation Centre.

2 NIUA. 1989. ***Upgrading Municipal Services: Norms and Financial Implications***. New Delhi: National Institute of Urban Affairs.

3 EPRTI. 1995. ***Status of Solid Waste Disposal in Metropolis***. Hyderabad: Environmental Protection Research and Training Institute.

4 CPCB. 1999. **Status of solid waste generation, collection and disposal in metrocities**. New Delhi: Central Pollution Control Board. [Central Urban Pollution Series: cups/46/1999/2000 (for 1994)]

Table 4.40A Characteristics of municipal solid waste (%) on weight basis: 1971 to 1973

City	*Paper*	*Plastics*	*Rags*	*Metals*	*Glass*	*Total compostable matter*
Ahmedabad	3.02	0.84	4.11	0.42	0.23	49.30
Ajmer	1.44	1.02	3.28	0.31	0.40	38.15
Allahabad	3.82	8.69	2.61	0.56	0.39	44.50
Aurangabad	4.51	0.28	3.36	0.52	0.67	36.30
Bangalore	1.91	0.32	0.75	0.32	0.21	53.83
Baroda	4.78	0.29	3.32	0.60	0.25	39.25
Bhopal	7.71	0.55	5.38	0.56	0.75	38.67
Bikaner	1.03	0.52	3.59	0.14	0.53	14.52
Chandigarh	6.17	8.33	5.24	0.22	0.21	34.74
Chennai	7.85	0.88	4.85	0.95	0.97	47.97
Coimbatore	3.08	0.13	4.24	0.54	0.40	35.24
Delhi	6.29	0.85	4.70	1.21	0.57	35.42
Gorakhpur	1.97	0.62	3.68	0.31	0.18	34.92
Guwahati	3.46	0.18	0.29	0.68	0.28	50.59
Gwalior	4.58	0.65	2.02	0.57	0.38	30.03
Howrah	4.62	0.71	2.75	0.16	0.29	34.99
Hyderabad	4.81	0.84	3.16	1.23	0.93	39.46
Indore	–	–	–	–	–	–
Jabalpur	2.01	0.69	1.68	0.39	0.36	39.87
Jaipur	3.03	0.80	5.98	0.61	0.39	25.89
Jodhpur	1.43	0.31	3.32	0.21	0.15	19.81
Kanpur	2.97	0.63	2.77	0.39	0.38	41.09
Kochi	–	–	–	–	–	–
Kolkata	3.18	0.65	3.60	0.66	0.38	40.38
Kota	1.09	0.27	2.70	1.13	0.22	48.76
Kozhikode	6.03	1.75	2.02	0.38	0.06	66.05
Kurnool	1.07	0.28	1.18	0.24	0.08	40.57
Lucknow	–	–	–	–	–	–
Ludhiana	–	–	–	–	–	–
Madurai	7.81	1.44	4.23	0.70	0.52	26.51
Mumbai	4.89	2.92	2.48	2.46	0.72	59.78
Nagpur	3.51	0.39	4.07	0.65	0.58	41.79
Patna	3.00	0.20	3.16	0.27	0.15	23.24
Pune	8.74	0.72	1.63	–	0.58	67.64
Raipur	1.83	0.66	1.31	0.44	0.23	38.44
Rajkot	1.44	0.53	1.35	0.50	0.14	55.38
Sangli	3.04	0.35	2.13	0.21	0.37	51.24
Surat	3.03	1.01	2.22	0.37	0.28	44.26
Tatanagar	3.48	0.45	2.43	0.45	0.33	27.38
Thane	5.50	1.00	2.25	0.30	0.25	53.00
Tiruchirapalli	5.57	1.62	6.36	0.29	1.28	45.99
Thiruvananthapuram	3.62	0.93	1.43	0.38	0.14	71.78
Udaipur	2.38	0.28	3.18	0.16	0.57	31.03
Varanasi	–	–	–	–	–	–
Vijayawada	–	–	–	0.14	0.27	31.94
Visakhapatnam	–	–	–	–	–	–

Sources

1 INSDOC. 1983. ***Solid Waste Management in Developing Countries.*** New Delhi: Indian National Scientific Documentation Centre.

2 EPRTI. 1995. ***Status of Solid Waste Disposal in Metropolis.*** Hyderabad: Environmental Protection Research and Training Institute.

Table 4.40B Characteristics of municipal solid waste (%) on weight basis: 1995

City	*Paper*	*Textile*	*Leather*	*Plastics*	*Rags*	*Metals*	*Glass*	*Ash, fine earth and others*	*Total compostable matter*
Ahmedabad	6.0	1.0	–	3.0	1.0	0	0	50.0	40.0
Bangalore	8.0	5.0	–	6.0	5.0	3.0	6.0	27.0	45.0
Baroda	4.0	–	2.0	7.0	–	–	–	–	40.0
Bhopal	10.0	5.0	–	2.0	5.0	–	1.0	35.0	45.0
Chennai	10.0	5.0	5.0	3.0	5.0	0	0	33.0	44.0
Coimbatore	5.0	9.0	–	1.0	9.0	0	0	50.0	35.0
Delhi	6.6	4.0	0.6	1.5	4.0	2.5	1.2	51.5	31.8
Hyderabad	7.0	1.7	–	1.3	1.7	0	0	50.0	40.0
Indore	5.0	2.0	–	1.0	2.0	0	0	49.0	43.0
Jaipur	6.0	2.0	–	1.0	2.0	0	2.0	47.0	42.0
Kanpur	5.0	1.0	5.0	1.5	1.0	0	0	52.5	40.0
Kochi	4.9	–	–	1.1	0	0	0	36.0	58.0
Kolkata	10.0	3.0	1.0	8.0	3.0	0	3.0	35.0	40.0
Lucknow	4.0	2.0	–	4.0	2.0	1.0	0	49.0	40.0
Ludhiana	3.0	5.0	–	3.0	5.0	0.0	0	30.0	40.0
Mumbai	10.0	3.6	0.2	2.0	3.6	0.0	0.2	44.0	40.0
Nagpur	4.5	7.0	1.9	1.3	7.0	0.4	1.2	53.4	30.4
Patna	4.0	5.0	2.0	6.0	5.0	1.0	2.0	35.0	45.0
Pune	5.0	–	–	5.0	0	0	10.0	15.0	55.0
Surat	4.0	5.0	–	3.0	5.0	0	3.0	45.0	40.0
Vadodara	4.0	–	–	7.0	–	–	–	49.0	40.0
Varanasi	3.0	4.0	–	10.0	4.0	0	0	49.0	48.0
Visakhapatnam	3.0	2.0	–	5.0	2.0	0	5.0	35.0	35.0
Average	5.7	3.5	0.8	3.9	–	1.9	2.1	40.3	41.8

Sources

1 INSDOC. 1983. ***Solid Waste Management in Developing Countries***. New Delhi: Indian National Scientific Documentation Centre.

2 EPRTI. 1995. ***Status of Solid Waste Disposal in Metropolis***. Hyderabad: Environmental Protection Research and Training Institute.

3 CPCB. 1999. **Status of solid waste generation, collection and disposal in metrocities.** New Delhi: Central Pollution Control Board [Central Urban Pollution Series: cups/46/1999/2000.] [For textile, leather, and ash, fine earth and others.]

Table 4.41 Status of municipal solid waste treatment and disposal in metro cities

City	*Solid waste collection (tonnes/day)*	*Treatment (tonnes/day)*	*Mode of disposal (%)*		
			Dumping	*Composing*	*Others*
Ahmedabad	1 683	84	95	5.0	–
Bangalore	2 000	200	90	10.0	–
Bhopal	546	100	82	18.0	–
Chennai	3 124	–	100	–	–
Coimbatore	350	–	100	–	–
Delhi	4 000	300	93	7.5	–
Hyderabad	1 566	100	94	6.0	–
Indore	350	50	86	14.0	–
Jaipur	580	–	100	–	–
Kanpur	1 200	300	75	25.0	–
Kochi	347	–	100	–	–
Kolkata	3 692	–	100	–	–
Lucknow	1 010	–	100	–	–
Ludhiana	400	–	100	–	–
Madurai	370	–	100	–	–
Mumbai	55 355	500	91	9.0	–
Nagpur	443	–	100	–	–
Patna	330	–	100	–	–
Pune	700	50	93	–	7
Surat	900	225	75	25.0	–
Vadodara	400	100	75	–	5
Varanasi	412	–	100	–	–
Visakhapatnam	300	–	100	–	–

Source

CPCB. 1999. **Status of solid waste generation, collection and disposal in metrocities.** New Delhi: Central Pollution Control Board [Central Urban Pollution Series: cups/46/1999-2000.]

Table 4.42 Status of municipal solid waste management in selected metro cities

City	*Bangalore*	*Kolkata*	*Chennai*	*Delhi*	*Mumbai*
Area (km^2)	226.16	187.33	174.00	1,484.46	437.71
Population (projected for 1999, in millions)	5.31	6.00	5.00	12.20	12.50
MSW generation (tonnes/day)	2 200	3 100	3 050	6 000	6 000
MSW per capita (kg/day)	0.41	0.52	0.61	0.49	0.48
Garbage pressure (tonnes/km^2)	9.73	16.55	17.53	4.04	13.71
Pressure on landfill	1 400	2 500	3 050	5 000	6 000
Safai Karmachari	12 600	12 030	10 130	40 483	22 128

Source

CPCB 1999. **Parivesh Highlights 1999.** p. 20. New Delhi: Central Pollution Control Board, Ministry of Environment and Forests.

Table 4.43 Status of hazardous waste generation in India

State / Union Territory	*Units generating hazardous waste* (no.)	*Quantity of waste generated (waste type)* (tonnes/year)			
		Recyclable	*Incinerable*	*Disposable*	*Total*
Andhra Pradesh	501	61 820	5 425	43 853	111 098
Assam	18	–	–	166 008	166 008
Bihar	42	2 151	75	24 351	26 577
Chandigarh	47	–	–	305	305
Delhi	–	–	–	–	59 423
Goa	25	873	2 000	3 725	8 742
Gujarat	2 984	26 000	19 953	150 062	430 030
Haryana	309	–	–	31 046	32 559
Himachal Pradesh	116	–	63	2 096	2 159
Karantaka	454	47 330	3 328	52 585	103 243
Kerala	151	84 932	5 069	690 014	780 015
Maharashtra	3 953	847 436	5 012	1 155 398	2 007 846
Madhya Pradesh	183	89 593	1 309	107 767	198 669
Orissa	163	2 841	–	338 303	341 144
Jammu and Kashmir	57	–	–	–	1 221
Pondicherry	15	8 730	120	43	8 893
Punjab	700	9 348	1 128	12 233	22 745
Rajasthan	306	9 487	19 866	2 242 683	2 272 036
Tamil Nadu	1 100	193 507	4 699	196 002	401 073
Uttar Pradesh	1 020	–	–	–	140 146
West Bengal	440	45 233	50 894	33 699	129 826
Total	12 584	1 429 281	118 941	5 250 173	7 243 758

Note

Total of recyclable, incinerable, and disposable columns will not add up due to waste sold or otherwise disposed

Source

MoEF. 2000. **Draft paper on status of implementation of the hazardous wastes rules, 1989.** New Delhi: Ministry of Environment and Forests.

Table 4.44 Mining waste (coal overburden removal) in the mechanized opencast mines (**million cubic metres**) in the Coal India Ltd: 1975/76 to 1992/93

Company	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1991/92*	*1992/93*
Eastern Coalfields Ltd	2.5	8.4	16.8	20.7	16.5	20.1
Bharat Coking coal Ltd	0.7	4.6	16.3	28.4	31.0	33.7
Central Coalfields Ltd	10.8	32.8	32.4	48.4	52.1	52.2
Northern Coalfields Ltd	–	–	28.0	89.4	89.1	83.0
Western Coalfields Ltd	7.3	16.9	22.9	35.7	41.3	44.8
South-Eastern Coalfields Ltd	–	–	30.1	60.2	65.4	48.2
Mahanadi Coalfields Ltd	–	–	–	–	–	23.6
North-Eastern Coalfields Ltd	–	–	2.9	1.1	3.8	4.0
Total	21.3	62.7	149.5	284.0	299.2	309.6

Source

CIL. 1993. ***Operational Statistics***. p. 43. Kolkata: Coal India Ltd.

Table 4.45 All-India distribution of deaths due to 10 selected diseases

Disease	*1988*	*1989*
Asthma and bronchitis	2 097	1 885
Heart attack	1 261	1 236
Pneumonia	1 204	1 190
Tuberculosis	1 222	1 106
Cancer	654	685
Anaemia	697	677
Vehicular accidents	0	446
Gastroenteritis	512	344
Typhoid	436	339
Acute abdomen	334	334
Dysentery	321	–
All causes	22 950	21 409

Source

CSO. 1998. ***Proceedings of the National Workshop on Environment Statistics***. p. 45.
New Delhi: Central Statistical Organization.

Table 4.46 Emission factors (g/kg) from cooking stoves for various fuel-stove combinations

Fuel and pollutant	*Conventional metal*	*Improved metal*	*Improved mud*
Total suspended particulates			
Fuelwood	1.3-2.7	1.1-3.8	1.8-2.1
Crop residues	2.1-5.0	2.1-2.0	3.5
Dung cakes	4.1- 5.3	4.2-7.8	7.4
Carbon monoxide			
Fuelwood	13.0-22.0	25.0-62.0	32.0-48.0
Crop residues	20.0-39.0	23.0-114.0	48.0
Dung cakes	11.0-16.0	34.0-67.0	46.0

Source

Ahuja D R *et al.* 1987. **Environmental performance of cookstoves in regard to thermal efficiency and emissions from combustion.** Submitted to the Ministry of Environment and Forests New Delhi: Tata Energy Research Institute. 131 pp.

For more details, please see TEDDY ONLINE+ [Section: Environment (air: domestic)]

Table 4.47 Concentration of pollutants as a result of burning biofuels

Location and type of stove	*Total suspended particulate matter* (mg/m³) *Sample size* (number)	*Average*	*Carbon monoxide* (parts per million) *Sample size* (number)	*Average*
Traditional				
Nepal	22	3.1	27	300
India				
Gujarat	45	6.4	–	–
Haryana	51	3.3	51	6
Karnataka	38	3.2	38	17
Central and South India	129	4.6	129	51
Pauri Garhwal	95	5.6	100	21
Tehri Garhwal	50	1.2	–	–
Pune, urban poor[a]	–	1.1	–	8
Ahmedabad, urban poor	20	2.6	20	165
Delhi slums[a]	80	1.2	80	12
Improved				
Nepal	27	1.1	26	67
India				
Gujarat	14	4.6	–	–
Haryana	36	2.9	36	5
Karnataka	38	2.5	38	8

[a] respirable particulate matter

Sources

1 Reid H, Smith K R, and Sherchand B. 1986. **Indoor smoke exposures from traditional and improved cookstoves: comparisons among rural Nepali women.** *Mountain Research and Development* 6(4).

2 Smith K R, Aggarwal A L, and Dave R M. 1983. **Air pollution and rural biomass fuels in developing countries: a pilot village study in India and implications for research and policy.** *Atmospheric Environment* 17(11).

3 Ramakrishna J. 1988. **Patterns of domestic air pollution in rural India.** PhD Dissertation, University of Hawaii.

4 Menon P. 1988. **Indoor spatial monitoring of combustion generated pollutants (total suspended particulates, carbon monoxide, and BAP) by Indian cookstoves.** PhD Dissertation, University of Hawaii.

5 Saksena S, Prasad R , Pal R C, Joshi V. **Patterns of daily exposure to total suspended particulates and carbon monoxide in the Garhwal Himalaya.** *Atmospheric Environment* 26(11): 2125-2134.

6 TERI. 1995. **Biomass fuels, indoor air pollution and health: a multi-disciplinary, multi-center study (phase 1B).** Final report submitted to Biomass Users Network, USA. New Delhi: Tata Energy Research Institute. 58 pp.

7 Raiyani C V, Shah S H, Desai N M, Venkaiah K, Patel J S, Parikh D J, Kashyap S K. 1993. **Characterization and problems of indoor pollution due to cooking stove smoke.** *Atmospheric Environment* 27A(11): 1643-1655.

8 TERI. 1995. **Health risks and cost-effective interventions for indoor air pollution.** Final report submitted to The Catholic University of Louvain, Belgium. New Delhi: Tata Energy Research Institute.

9 Smith K R, Apte M G, Yuqing M A, Wongsekiarttirat W, Kulkarni A. 1994. **Air pollution and the energy ladder in Asian cities.** *Energy* 19(5): 587-600.

Now available . . .

The most comprehensive, up-do-date and timely information on recent happenings in oil and gas, power and coal sector at your desk-top . . .

For updates on

- India's current oil deficit
- Power reforms
- Clean technology
- Energy industry performance
- Coal supply norms
- Joint ventures and tie-ups
- Investment in energy sector
- Hydrocarbon sector restructuring

. . . and many more topics

TERI Newsflash,
the electronic news update

- Timely news at your desktop every week
- Focus on oil and gas, power and coal
- Condensed and arranged for easy scanning

Here is what you get

- Weekly digest of news
- Daily news headlines
- 24-hour access to the database of past news on the Web

What you have to pay yearly

Oil and gas: Rs 10 000 / US $400
Power and coal: Rs 10 000 / US $400
Both: Rs 15 000 / US $600

All order and enquires to

TERI
Information Dissemination Services
Darbari Seth Block, Habitat Place
Lodhi Road, New Delhi – 110 003

Fax +91 11 468 2144 or 468 2145
E-mail outreach@teri.res.in
Telephone +91 11 468 2100 or 468 2111
Web site www.teriin.org

Visit our online catalogue at www.teriin.org/pub/

Global environment issues

At a glance

- The *2000 IUCN Red List of Threatened Species* indicates that species extinction is on an increasing spiral. Since the last assessment in 1996, the number of CR (critically endangered) primates has increased from 13 to 19 and the number of mammals from 169 CR and 315 endangered to 180 CR and 340 endangered mammals.
- India, with 80 species, has moved ahead of China (72 species) in terms of the most number of mammals under threat.
- CoP-6, the sixth meeting of the Conference of the Parties to the CBD (Convention on Biological Diversity), will be held The Hague during 8 to 19 April 2002.
- The decision to develop a strategic plan for the CBD was taken at CoP-5 (Decision V/20) initially to cover the period 2002–10.
- The assessment of the implementation of national reports has been taken up by the United Nations Environment Programme and World Conservation Monitoring Centre.
- Implementation of the CBD is to be strengthened, including implementation and provision of final support for national biodiversity strategy and action plans and filling of policy gaps.
- Rules for the formal regulation of ozone-depleting substances phase-out have been notified in the *Gazette of India* on 19 July 2000 and are called Ozone Depleting Substances (Regulation and Control) Rules, 2000.
- During 2000, the Multilateral Fund approved 35 investment and 11 non-investment projects for India worth about 10.8 million dollars, which will phase out 9158 ozone-depleting potential tonnes when completed.
- The IPCC (Intergovernmental Panel on Climate Change) in its Third Assessment Report (IPCC Secretariat 2001) has confirmed that the evidence of human interference in the climate is stronger than ever. The atmospheric concentrations of carbon dioxide (CO_2), methane, and nitrous oxide have grown by about 31%, 151%, and 17%, respectively, over the period 1750–2000.
- Mean global surface temperature has increased by 0.6 °C (+0.2 °C) over the 20th century, with the 1990s being the warmest decade since 1860, i.e. the period of instrumental record.
- Developing countries such as India are more vulnerable to the effects of climate change due to their high dependence on climate-sensitive sectors such as agriculture and forestry, and their low technical and financial adaptive capacity.
- The parties to the Framework Convention on Climate Change adopted the Kyoto Protocol on 11 December 1997, whereby Annex I Parties (developed countries) agreed to reduce their overall emissions of six greenhouse gases by at least five per cent below the 1990 levels between 2008 and 2012.
- In July 2001, in the resumed session of CoP-6 at Bonn, ministers and senior government officials approved a political agreement that would help move towards the adoption of the Kyoto Protocol.

Biological diversity

Biological diversity or biodiversity is defined as the variety and variability among living organisms and the ecological complexes in which they occur, and is measured at three levels—the gene, the species, and the ecosystem. Globally, biodiversity is facing a barrage of threats in the form of loss and fragmentation of habitats; over-exploitation; spread of exotic species and diseases; air, soil, and water pollution; and climate change, leading to widespread extinction of species (Soule 1991). During the past 400 years, nearly 400 vertebrates, including around 88 mammals, more than 100 birds, and 320 invertebrates, have become extinct, leading to an extinction rate that is approximately 100–200 times higher than the background extinction rate of about 1 species of birds and mammals every 5000 years (Groombridge and Jenkins 2000).

The global extinction crisis

The 2000 IUCN (World Conservation Union) *Red List of Threatened Species* (IUCN 2000) indicates that species extinction is on an increasing spiral (Tables 4.48 and 4.49). Since the last assessment of globally threatened species in 1996, the number of CR (critically endangered) primates has increased from 13 to 19. While the 1996 IUCN *Red List of Threatened Animals* listed 169 CR and 315 endangered mammals, the 2000 analysis lists 180 CR and 340 endangered mammals. Similarly, for birds, there is an increase from 168 to 182 CR and from 235 to 321 endangered species. As many as one in four mammal species and one in eight bird species are threatened, and the number of threatened animal species has increased from 5201 to 5435. Approximately 25% of reptiles, 20% of amphibians, and 30% of fish (mainly freshwater) are listed as threatened. The number of CR reptiles has increased from 10 to 24 and endangered from 28 to 47 species. Turtles and tortoises, in particular, are greatly threatened. The number of species of CR freshwater turtles went up from 10 to 24 CR species from 1996 to the 2000 IUCN assessment, and this can be ascribed to unregulated harvests for food and medicines. Trends suggest that the trade in turtles after depleting populations in South-East Asia is shifting to the Indian subcontinent and even to the Americas and Africa.

Madagascar has the most CR and endangered primates and has lost 90% of its original vegetation. Indonesia harbours the highest numbers of threatened mammals and both India (80 species) and Brazil (75 species) have moved ahead of China (72 species) in terms of the numbers of mammals under threat. The Philippines has lost 97% of its original vegetation and has more CR birds than any other country. The most threatened birds are in tropical Central and South America and in South-East Asia. Indonesia has the highest number of threatened birds (115), followed by Brazil (113), Colombia (78), China (76), India (74), and Peru (75). Plant species are declining in South and Central America, Central and West Africa, and South-East Asia. Malaysia has the highest number of threatened species (681) including a large proportion of tropical timber trees, followed by Indonesia, Brazil, and Sri Lanka with 384, 338, and 280 species, respectively. Globally, the number of threatened plants listed is 5611, but this is based on an assessment of only four per cent of the world's total described plants. Therefore, the percentage of threatened plant species is likely to be much higher (IUCN 2000).

Habitats with the highest number of threatened mammals and birds are lowland and mountain tropical forests. Forty per cent of all fish species and 12% of all animal species live in freshwater habitats (Gleick 1993); yet these ecosystems are particularly vulnerable to species extinction. Freshwater ecosystems have lost a greater proportion of their species and habitats than terrestrial or marine ecosystems have, although they cover only one per cent of the earth's land surface. It is estimated that half of the world's wetlands were lost in the 20th century due to conversion of land to agriculture and urban areas (WRI 2000). The major causes for changes in freshwater ecosystems are pollution, dams, over-fishing, siltation, and introduction of exotics. Lake Victoria has a tremendous diversity of fish—350 species of a single fish family, the cichlids, were found here (Abramovitz 1996). But non-native species have driven 200 species of cichlids to extinction, with 150 more being on the brink.

Major causes of biodiversity loss

The major proximate causes of species extinction continue to be habitat loss and degradation, which are affecting 89% of all threatened birds, 83% of mammals, and 91% of all threatened plants assessed (IUCN 2000). The main causes of habitat loss are agricultural activities, extraction (including mining, fishing, logging, and harvesting) and development (human settlements, industry, associated infrastructure). Exploitation, including hunting, collecting, fisheries and fisheries by-catch, and the impacts of trade in species and species' parts, are a major threat to birds (37%), mammals (34%), plants (8% of those assessed), reptiles, and marine fishes. Alien invasive species are a significant threat, affecting 350 (30%) of all threatened birds and 361 threatened plant species (15%). Islands are particularly susceptible to invasion by alien species.

The underlying causes of biodiversity loss, however, are poverty, macro-economic policies, international trade factors, policy failures, poor environmental law/weak enforcement, unsustainable development projects, and lack of local control over resources (Table I) (Wood, Stedman-Edwards, and Mang 2000)

Future threat to biodiversity and climate change

Besides the threats to which biodiversity is already subject, climate change appears to be yet another ominous hazard that will afflict biodiversity in the future. Data on the potential effects of climate change on biodiversity are limited. However, some studies indicate that climate change could lead to significant species loss (Malcom and Markhan 1996, 1997). In the past, climatic changes have led to shifts in vegetation types, but the current rate of global warming is expected to cause much more significant changes. In a study using linked global climate and vegetation models including seven climate models and two biogeographic models that can map the potential future distributions of major vegetation types (biomes), 14 impact scenarios were generated (Malcom and Markhan 2000). The study investigated three possible threats to global biodiversity from global warming.

1 Rising rates of global warming may exceed the migrational capacity of species
2 Losses of habitat during progressive shifts of climatic conditions
3 Reductions in species diversity through reductions in patch size of habitats.

Some of the conclusions of this study are as follows.

- Very high RMRs (required migration rates) (≥1000 m/year) were common comprising, on an average, 17% and 21% of the world's surface from two vegetation models. Owing to

Table I Underlying causes of biodiversity loss

Pressures/responses	*Brazil*	*Cameroon*	*China*	*Danube basin*	*India*	*Mexico*	*Pakistan*	*Tanzania*	*The Philippines*	*Vietnam*
Domestic pressures										
Population growth	●	●	■		●	■	■		■	■
Poverty		■	■	●	■	■	●	■	■	■
Immigration	●	●			●	■	■		■	■
Inequality	■					●	■		■	
Isolation/marginalization			●	●		■		■		
Cultural changes		■			●	●	■	●	●	●
International pressures										
Macroeconomic policies	■	■		■	■		■			●
International trade factor	■	■			■	●	●		■	●
Policy responses										
Policy failure	■	■	■	■	●	●	●	●	■	■
Domestic market factors	●	■	■	●	●			■		■
Poor environmental law/weak enforcement	●	■	●	●	●	■	●	●	●	■
Unsustainable development projects	●				■		■	●		
Lack of local control over resources	●	■	●	■	■	●	■	●		●

● Cause of biodiveristy loss, ■ Very important cause of biodiversity loss
Source Wood A, Stedman-Edwards P, and Mang J (eds) (2000)

global warming, RMRs for plant species appeared to be 10 times higher than those recorded from the last glacial retreat. This translates into a high rate of species extinction and local extirpations of both plant and animal species.

- The highest RMRs are predicted to be in the taiga, tundra, temperate evergreen forest, temperate mixed forest, and boreal coniferous forest. The 20 countries in the world that have the highest RMR are given in Table 4.50.
- Global warming has the potential to destroy 35% of the world's terrestrial habitats.
- Loss of local species due to doubling of carbon dioxide may be as high as 20% in the most vulnerable arctic and montane habitats due to reduction in the size of habitat patches and fragments.
- Invasive species and others with high dispersal capabilities are likely to suffer few problems, therefore, pests and weedy species are likely to dominate several landscapes.

Protecting and managing biodiversity

Over the years, various approaches have been tried to conserve the earth's biological resources, including efforts in the spheres of economics, biology, policy, law, institutional measures, etc. Countries set up a system of PAs (protected areas) – such as sanctuaries and national parks – cordoning off areas of biodiversity value. Increasingly, however, the focus on conservation has shifted beyond PAs to biodiversity lying outside PAs and its protection through the involvement of local communities. This includes, amongst many, the CAMPFIRE (Communal Areas Management Programme For Indigenous Resources) initiatives in Zimbabwe and the joint forest management approach in India to regenerate degraded forests.

Community involvement in conservation is essential to the management of natural resources. Nonetheless, a recent study has indicated that PAs too have been effective in protecting tropical biodiversity despite pressures on them (Bruner, Gullison, Rice, et al. 2001). Ninety-three PAs in 22 tropical countries were studied, and more than 80% of the parks were found to be in a better condition than their surroundings as regards clearing, logging, and fire. About 60% of the parks were in a better condition than land outside their borders with respect to hunting and grazing. As many as 43% of the parks had no net clearing since establishment; in another 40% of parks, land formerly under cultivation was incorporated into park boundaries and had been able to recover (Figure 1). In general, 'park effectiveness correlates with basic management such as enforcement, boundary demarcation, and direct compensation to local communities suggesting that even modest increases in funding would directly increase the ability of parks to protect tropical biodiversity' (Bruner, Gullison, Rice, et al. 2001).

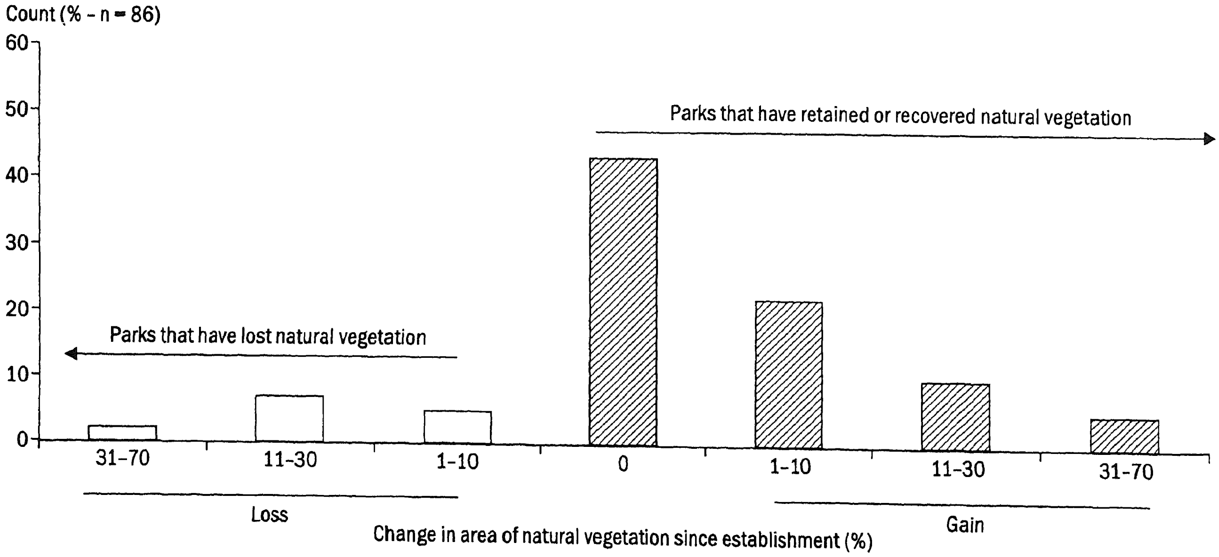


Figure 1 Change in the area of natural vegetation since establishment of 86 tropical parks

Prioritizing areas of high biodiversity value

The dwindling status of biodiversity, accentuated by limitations of available conservation resources, has forced conservationists to not only identify threatened species but also to prioritize areas of ecological and conservation value. Several different approaches have been developed for prioritizing areas of biodiversity value including an identification of 'megadiversity' countries and its extension to estimates of richness and endemism in land vertebrates and vascular plants for all countries, identification of important centres of plant diversity, global assessments of endemic bird areas, i.e those areas with the co-occurrence of restricted range species (those in which the area encompassing all distribution records is less than 50 000 km^2), apart from hotspots and ecoregions that focus on regions of high diversity or representative ecosystems.

Biodiversity hotspots

The identification of 18 biodiversity hotspots in the 1980s (Myers 1988) was an outcome of a priority-setting exercise in which India figured with two hotspots—the Western Ghats and the Eastern Himalayas. Recently, Myers and a team of scientists have brought out an updated list of 25 hotspots (Myers, Mittermeier, Mittermeier, et al. 2000). These hotspots represent an improvement over the earlier classification, with an expanded criteria for selection. These 25 hotspots (Table 4.51), covering a mere 1.4% of the land surface of the earth, harbour remaining habitats of 133 149 plant species (44% of all species of vascular plants) and 9645 vertebrate species (35% of all the vertebrate species). These are highly threatened habitats and have already lost 88% of their primary vegetation.

Some hotspots are richer than others in terms of their contribution to biodiversity. Each of the five hotspots – the Tropical Andes, Sundaland, Madagascar, Brazil's Atlantic forest, and the Caribbean – have endemic plants and vertebrates amounting to at least two per cent of the total species worldwide. Together, they comprise 20% of all plants, 16% of all vertebrates, and 45% of all the plants and vertebrates endemic to the 25 hotspots, but cover a mere 0.4% of the earth's land surface. The Western Ghats/Sri Lanka and the Indo-Burma region (covering the Eastern Himalayas) are in the top eight most important hotspots (Table 4.52).

The 200 global ecoregions

Another approach to prioritizing biodiversity is the ecoregional one focussing on representation of the earth's distinctive ecosystems. The WWF (World Wide Fund) 200 Global Ecoregions analysis that was conducted by Olson and Dinerstein (1998) identified 233 ecoregions (the Global 200) that are outstanding examples of the world's diverse ecosystems and priority targets for conservation action, which represent the Earth's 19 terrestrial, freshwater, and marine habitat types. These include 136 terrestrial, 36 freshwater, and 61 marine ecoregions. Selection of ecoregions was based on analyses of species richness, species endemism, unique higher taxa, unusual ecological or evolutionary phenomena, and global rarity of major habitat types. Outstanding ecoregions within each major habitat type from each of the world's biogeographic realms and ocean basins were selected to best capture the variation in species assemblages around the world. Unlike the 'hotspot approach', which focuses only on species-rich and high endemic areas, the ecoregional approach also focuses on the other 50% of all species that are found in areas other than the world's tropical moist forests. To conserve this half, a full representation of the world's diverse ecosystems must be the goal (Olson and Dinerstein 1998). According to Olson and Dinerstein (1998), 'tundra, tropical lakes, mangroves, and temperate broadleaf forests are all unique expressions of biodiversity. Although they may not support the rich communities seen in tropical rainforests or coral reefs, they contain species assemblages adapted to distinct environmental conditions and reflect different evolutionary histories. To lose representative examples of these assemblages and the evolutionary phenomena they contain would represent an enormous loss of biodiversity.'

Such analyses that provide a clue to the most biodiverse regions of the world are an extremely important step in natural resource conservation and can help focus funding on globally and regionally important areas that are of conservation value.

International treaties: the Convention on Biological Diversity

The CBD (Convention on Biological Diversity) is a legally binding framework treaty that has been ratified to date by 180 countries. The CBD

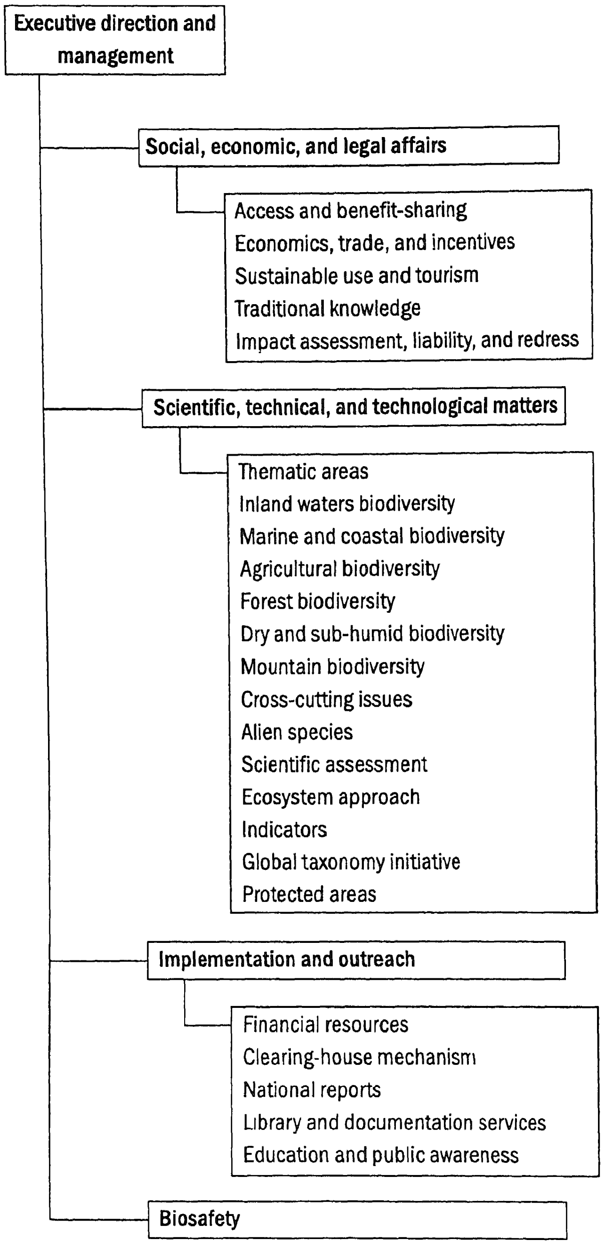

Executive direction and management
Social, economic, and legal affairs
Access and benefit-sharing
Economics, trade, and incentives
Sustainable use and tourism
Traditional knowledge
Impact assessment, liability, and redress
Scientific, technical, and technological matters
Thematic areas
Inland waters biodiversity
Marine and coastal biodiversity
Agricultural biodiversity
Forest biodiversity
Dry and sub-humid biodiversity
Mountain biodiversity
Cross-cutting issues
Alien species
Scientific assessment
Ecosystem approach
Indicators
Global taxonomy initiative
Protected areas
Implementation and outreach
Financial resources
Clearing-house mechanism
National reports
Library and documentation services
Education and public awareness
Biosafety

Figure 2 Institutional structure of the Convention on Biological Diversity
Source CBD Secretariat (2001)

has three main thrust areas: conservation of biodiversity, sustainable use of biological resources, and equitable sharing of benefits arising from its sustainable use. The Convention has five basic institutional structures (Figure 2).

1. The CoP (Conference of Parties) established under Article 23 to review the Convention's implementation.
2. The SBSTTA (Subsidiary Body on Scientific, Technical and Technological Advice), which is an intergovernmental scientific advisory body.
3. The Secretariat to prepare and service meetings for the Convention.
4. The GEF (Global Environment Facility) for providing financial resources to developing countries on an interim basis.
5. The CHM (clearing-house mechanism) to facilitate technical and scientific cooperation.

The CoP has initiated work on five thematic work programmes addressing marine and coastal biodiversity, agricultural biodiversity, forest biodiversity, biodiversity of inland waters, and dry and sub-humid lands. Besides the thematic programmes, there are key cross-cutting issues that are relevant to all the above thematic areas. Essentially, these correspond to the issues addressed in the Convention's substantive provisions in Articles 6–20. For example, work has been initiated on biosafety; access to genetic resources; traditional knowledge, innovations and practices (Article 8(j)); intellectual property rights; indicators; taxonomy; public education and awareness; incentives; and invasion of alien species (CBD Secretariat 2001).

The CoP-6, the sixth meeting of the CoP to the CBD, will be held in The Hague during 8–19 April 2002. If the Cartagena Protocol on Biosafety enters into force early enough, then the first meeting of the Parties to the Protocol will be held in conjunction with CoP-6. At its sixth meeting, the CoP is expected to review the implementation of the programme of work, and to focus on issues of forest biological diversity; invasive alien species; access and benefit-sharing; national reporting by countries on the progress made in implementing the Convention, etc.

Progress of the biosafety protocol

The CoP to the CBD adopted a supplementary agreement to the Convention known as the Cartagena Protocol on Biosafety on 29 January 2000. The Protocol seeks to protect biological diversity from the potential risks posed by LMOs (living modified organisms) resulting from modern biotechnology. It establishes an advanced informed agreement procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory. The Protocol has been hailed as a breakthrough due to its emphasis on the precautionary approach as a principle of international environmental law and puts the environment on a par with trade-related issues in the international area (CBD Secretariat 2001). The Protocol will also establish a series of mechanisms that have the potential to make a significant contribution to technology transfer, in particular biotechnology. The Protocol is a means for developing countries to gain access to information and technology, provided the Protocol enters into force and its institutions prove to be effective. The Protocol has also established a Biosafety Clearinghouse to facilitate the exchange of information on LMOs and to assist countries in the implementation of the Protocol (CBD Secretariat 2001).

In decision EM-I/3, the CoP established an open-ended ad hoc ICCP (Intergovernmental Committee for the Cartagena Protocol) on Biosafety to undertake preparations for the first meeting of the Parties to the Protocol. The first meeting of the ICCP was held in Montpellier, France, during 11–15 December 2000, which was attended by 578 participants from 82 governments and 133 United Nations bodies, intergovernmental, non-governmental, and industry organizations. The meeting considered issues that had been identified by the CoP-5 for the first meeting of the ICCP, such as information sharing and the Biosafety Clearinghouse; capacity building; decision-making procedures; handling, transport, packaging, and identification; and compliance. The second meeting of the ICCP is scheduled for 1–5 October 2001 in Nairobi, Kenya (CBD Secretariat 2001).

To date, 96 countries have signed the Protocol, and Bulgaria, Norway, and Trinidad and Tobago have ratified the Protocol. India signed the Cartagena Protocol on Biosafety on 23 January 2001 and has been appointed to represent Asia on the 10-member bureau of the ICCP.

Implementation of the Convention and development of a strategic plan

Since the Convention's inception, the CoP has taken over 100 decisions and launched programmes of work to address 5 biome-based themes and 13 cross-cutting issues. The following steps, however, remain to be taken to strengthen implementation.

- *Implementing NBSAP (National Biodiversity Strategy and Action Plans)* More than 100 parties have begun to develop NBSAPs. Transforming these documents into action is the next critical step. The Convention will need to focus on providing financial support for their implementation.
- *Filling policy gap areas* The Convention has proven to be an effective vehicle for developing policy. In particular, it has established the basic institutional framework and a modus operandi that has begun the process of considering most of the areas or topics raised by the Convention. There remain, however, a number of key provisions that have not been considered by the CoP (CBD Secretariat 2001). These include
  - Article 8(f) and rehabilitation of ecosystems and recovery of threatened species;
  - Article 9 and the role of *ex situ* collections;
  - Article 12 and research and training;
  - Article 18 and technical and scientific cooperation; and
  - polar and urban ecosystems.
- *Intersectoral cooperation and mainstreaming of biodiversity* Integrating the issues and concerns raised by the Convention into the plans and activities of a wide range of sectors is crucial to implementing the Convention. This provision has, however, proven difficult. For example, even though many parties have established multi-departmental committees to mainstream, several of these committees have had little or no impact on overall government policies. Mainstreaming can, therefore, additionally be promoted through other such means as environmental impact assessments, which ultimately ensures that projects or policies take biodiversity factors into consideration. Various economic tools also support intersectoral integration through ensuring that activities incorporate the costs to biodiversity. Two important mechanisms for this are certification schemes and developing methods for valuing biodiversity in national accounting systems (CBD Secretariat 2001).

Development of a strategic plan

Unlike other conventions, the provisions of the CBD provide overall goals and policies that can guide decision-making at the national level.

Precise obligations, timetables, targets, and lists of habitats and species to be protected are missing from its provisions. To enhance implementation of the Convention, the CoP at its fifth meeting (Decision V/20) decided to initiate a process to develop a strategic plan for the Convention. This plan will be open for consideration and adoption at the CoP-6. This plan is to initially cover the period 2002–10 and contain operational goals relating to (1) thematic programmes, (2) cross-cutting issues and initiatives, and (3) implementation of the provisions of the Convention. The main purpose of the strategic plan is to support and facilitate implementation of the Convention by Parties, primarily through their national biodiversity strategies and action plans, and be based on those areas identified in the first national reports which are in need of coordination, support, and collective endeavour. To date, 86 first national reports have been submitted while the second national reports were due by 15 May 2001 for discussion at CoP-6. National reports are to be submitted every four years. CoP-5 recommended that Parties prepare their reports through a consultative process in accordance with standard formats developed by the CBD Secretariat. Work on assessing national implementation has been taken up by UNEP's (United Nations Environment Programme) WCMC (World Conservation Monitoring Centre).

The Indian scenario

India has a rich and varied heritage of biodiversity covering 10 biogeographic zones: the trans-Himalayan, the Himalayan, the Indian desert, the semi-arid zone(s), the Western Ghats, the Deccan Peninsula, the Gangetic Plain, North-East India, and the islands and coasts (Rodgers and Panwar 1988). Surveys conducted so far in India have inventorized over 47 000 species of plants and over 89 000 species of animals over 70% of the country's total area. Amongst plants, significant diversity has been recorded in Pteridophytes (1022) species and Orchidaceae (1082 species) (Table 4.53). A total of 89 317 animal species have been recorded in India, accounting for 7.31% of the faunal species in the world (Table 4.54). The endemism of Indian biodiversity is high: about 33% of the country's recorded flora are endemic to the country and is concentrated mainly in the North-East, Western Ghats, North-West Himalayas, and the Andaman and Nicobar Islands (Table 4.55). About 62% of the known amphibian species are endemic to India, the majority occurring in the Western Ghats, nearly 50% of the lizards of India are endemic, with a high degree of endemicity in the Western Ghats (Table 4.56). India is a centre of crop diversity—the homeland of 167 cultivated species and 320 wild relatives of crop plants (Table 4.57). However, under the global statistics of biodiversity loss, India has several endangered and threatened species. The 2000 IUCN *Red List of Threatened Species* is provided in Tables 4.58, 4.59, and 4.60.

Conservation initiatives in India

The high degree of pressure on India's ecosystems, stemming from a variety of reasons, warrants focused actions to protect and preserve India's biodiversity. Over the years, the government has initiated several activities for the protection of India's biodiversity, such as the creation of national parks, sanctuaries, biosphere reserves, the promulgation of the Wildlife (Protection) Act of 1972 as amended in 1991, participation in several international conventions such as the CBD and the Convention on the International Trade in Endangered Species of Fauna and Flora.

Besides forest biodiversity, wetland conservation has been a priority issue of the government since the late 1980s. Conservation initiatives included identifying wetlands of conservation value and framing policy guidelines. To coordinate this activity, a National Committee on Wetlands, Mangroves and Coral Reefs was created, which identified 19 wetlands. The central government funded numerous conservation activities such as data collection and surveys, wetland mapping, landscape planning, wildlife development, and fisheries control. This led in 1993 to the formation of a National Lake Conservation Plan focusing in particular on urban lakes. To date, 11 lakes have been identified for conservation and management. On the international front, India is a signatory to the Ramsar Convention, 1971, under which 881 wetland areas covering an area of 62.77 million hectares have been designated by 101 contracting parties. India has 6 Ramsar wetlands—Keoladeo National Park, Bharatpur; Sambar, Rajasthan; Chilka, Orissa; Loktak, Manipur; Wullar, Jammu and Kashmir; and Harike, Punjab.

In 1986/87, the Indian government initiated a programme on the conservation and management of mangroves and coral reefs and a national committee was constituted in this regard to advise the government on policy and management aspects of mangrove ecosystems. Fifteen mangroves and four coral reefs were identified for conservation and management, and state-level steering committees have been formed to coordinate the implementation of management action plans for these areas. This year, another 15 mangrove areas have been added to the list, including Subernarekha, Devi, and Dhamra in Orissa; Ramnand in Tamil Nadu; Dakshin Kannada in Karnataka; Devgarh, Vijaydurg, Veldur, Kundlika, Revdanda, Mumbra-Diva, Vaitrana, Vasai Manori, Shreevardhan–Varal–Turmbadi, and Kalsuri in Maharashtra.

The major reef formations in India are found in the Gulf of Mannar, Palk Bay, Gulf of Kachchh, Andaman and Nicobar Islands, and Lakshadweep Islands. Primary, fragile coral reefs that are of priority value for conservation include Lakshadweep, Andaman and Nicobar Islands, Gulf of Mannar, and Gulf of Kachchh. The Indian Coral Reef Monitoring Network was set up to cover activities relating to coral reefs including research and monitoring, training and capacity-building, establishment of a database, etc.

Maintaining viable populations of species, whether plant or animal, is a crucial factor in biodiversity conservation, and this requires the appropriate conservation of important ecosystems and habitats. The country now has 12 biosphere reserves (Table 4.61), of which the Nilgiri BR has been approved for inclusion within the International Network of Biosphere Reserves recognized by UNESCO (United Nations Educational, Scientific, and Cultural Organization). The World Heritage sites located in India are given in Table 4.62. Amongst PAs, India has 88 national parks and 490 sanctuaries covering an area of 153 000 km^2. Financial assistance was provided to 157 national parks and sanctuaries in which 100% assistance is provided from the centre for non-recurring items of expenditure for both parks and sanctuaries, and 50% assistance is provided for recurring expenditures for national parks. However, in a significant step towards the management of PAs from this year, PAs in mountains, deserts, and coastal areas supporting large populations of endangered species such as the snow leopard, red panda, rhino, sangai deer, pharys' leaf monkey, musk deer, hangul, great Indian bustard, chinkara, and blackbuck are now eligible for 100% assistance from the centre for recurring items of expenditure.

Rodgers and Panwar (1988) conducted a comprehensive study in which they drew up plans for a PA network to cover the range of biological diversity in the country. They suggested that the percentage of the country's area under the network, which was only 3.3% then, be enhanced to 4.6%. The recent update suggests that the number of national parks be increased to 160 and sanctuaries to 698, accounting for 5.69% of the country's geographical total (Rodgers, Panwar, and Mathur 2000). This coverage will provide a 'better distribution of protected areas with less gaps in the protection of biogeographic zones, biomes and species and fewer spatial or geographic gaps in the pattern of PA coverage' (Rodgers, Panwar, and Mathur 2000). Table 4.63 provides a listing of existing and proposed PAs by biogeographic zone.

Project Tiger, initiated in 1973 to maintain viable populations of the tiger and its natural habitat, has grown over the years to 27 tiger reserves in 14 states and cover an area of 37 761 km^2 (Table 4.64). Under the Ninth Five Year Plan, six new tiger reserves have been proposed with project allowances to the field staff of tiger reserves as an incentive for officials working in harsh conditions along with the deployment of paramilitary forces in troubled tiger reserves with 100% assistance from the Centre. Under Project Elephant, during the last year, 90 million rupees was allocated to elephant range states. Tripura, Mizoram, and Manipur were also asked to conduct elephant census.

Policy and institutional initiatives

The Biodiversity Bill was introduced in the Lok Sabha in 2000 and was referred to the Department Related Parliamentary Standing Committee on Science, Technology, Environment and Forests for further examination. The draft amended Bill for the revision of the Wildlife (Protection) Act, 1972, has been prepared and sent to the law ministry before obtaining cabinet approval (MoEF 2000b). The GEF-funded National Biodiversity Strategy and Action Plan development process is well under way. The Indian Institute of Biodiversity that will conduct biodiversity research is being set up at Itanagar, Arunachal Pradesh (MoEF 2000b). The Deshmukh Committee has prepared a draft updated National Wildlife Action Plan and the Indian Board of Wildlife has also been reactivated and a meeting was convened on 14 June 2000.

Stratospheric ozone depletion

Ozone forms a layer 10–50 km above the earth's surface, which absorbs most of the harmful UV (ultraviolet radiation) from the sun. Concerns that this layer could be at risk from CFCs (chlorofluorocarbons) and other anthropogenic substances were first raised during the 1970s. The ozone layer over the Antarctic has steadily weakened since measurements started in the early 1980s.[1] The land area under the ozone-depleted atmosphere increased to more than 20 million km^2 in the early 1990s and has varied between 20 and 26 million km^2 since then. In the Antarctic spring (August to November) of 1998, the area of the ozone hole reached 26 million km^2, and covered some populated areas of the southern hemisphere. In 1999, the ozone hole had an average area of 22 million km^2 (UNEP 2000). This was the second largest and strongest ozone-hole phenomenon observed (WMO 1999).

As the ozone layer thins, more damaging UV-B radiation reaches the earth's surface, leading to grave consequences for human and ecological health. This increased radiation can change genetic structure, alter immune systems, inhibit plant growth, and increase the occurence of skin cancer and cataracts.

In 1974, Sherwood Rowland and Mario Molina showed that ozone destruction is caused by chlorine and bromine atoms produced by the break-up of CFCs and halons in the atmosphere. CFCs are long-lived human-made chemicals that are commonly used in refrigeration systems, air conditioners, aerosols, solvents, and in the production of some types of packaging. Table 4.65 illustrates the trends in atmospheric concentrations of some of these ozone-depleting compounds. Before industrialization, natural atmospheric chlorine levels were only 0.6 PPBV (parts per billion by volume). At present, however, the concentration of chlorine compounds has risen to 3.0–3.5 PPBV (UNEP 1992).

The first attempt to address the problem of stratospheric ozone depletion was made in 1981 with the onset of inter-governmental negotiations for an international agreement to phase out ODS (ozone–depleting substances). In 1985, the same year that the ozone hole over Antarctica was discovered, the Vienna Convention for the protection of the ozone layer was adopted. This Convention created a general obligation for countries to take appropriate measures to protect the ozone layer. Although it did not define these measures, it succeeded in establishing a mechanism for international cooperation and laid down the framework for a future legally binding protocol to control ODS (Benedick 1998).

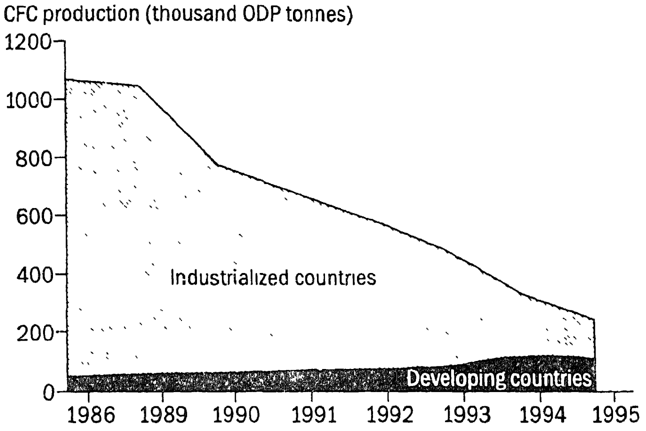
The Montreal Protocol

The Montreal Protocol on substances that deplete the ozone layer was adopted on 16 September 1987. Under the Protocol, the developed countries agreed to reduce production and consumption of CFCs to half of 1986 levels by 1999. Developing countries having a per capita consumption of ODS lower than 0.3 kg were granted a grace period before taking on commitments. Subsequently, the Montreal Protocol was strengthened through amendments made at London in 1990, Copenhagen in 1992, Vienna in 1995, Montreal in 1997, and Beijing in 1999 to accelerate the phase-out schedule of ODS. These amendments have also introduced new control measures, covered more controlled substances, and imposed tighter restrictions for developing countries. The Beijing Amendment included bromochloromethane for immediate phase-out and introduced production controls and control of trade with non-Parties for HCFCs (hydrochlorofluorocarbons). As of June 2001, 176 countries have ratified the Montreal Protocol. The timetable for the phase-out of ODS under the Protocol and its subsequent amendments are given in Table 4.66.

The Montreal Protocol has resulted in a sharp decline in the manufacture and use of CFCs. In 1986, total global consumption of CFCs was 1.1 million tonnes; by 1997, this had fallen to 164 000 tonnes (UNEP 2000). Figure 3 shows the decline in annual production of CFCs. It is estimated that in the absence of the Montreal

---

[1] In the troposphere, however, the concentration of ozone in the northern middle latitudes has more than doubled in the last 100 years, primarily due to combustion processes.



Note ODP (Ozone depleting potential) tonnes is a measure by which ozone depleting substances are weighted according to their ability to destroy ozone

Figure 3 Annual production of CFCs (chlorofluorocarbons): 1986-95

Source Oberthur (1997)

Protocol, the global consumption of CFCs would have increased to 3 million tonnes by 2010 and 8 million tonnes by 2060. By 2050, ozone depletion would be 10 times worse than current levels, causing 19 million more cases of non-melanoma cancer, 1.5 million more cases of melanoma cancer, and 130 million more cases of eye cataracts (UNEP 2000). Projections of ozone losses with and without the Protocol are illustrated in Figure 4. Figure 5 shows the potential deaths averted by the Montreal Protocol.

International cooperation on ozone depletion has been largely successful due to the development of alternatives to ODS at relatively low cost. However, there is an increasing trend in the atmospheric concentrations of halons, which are used in firefighting equipment, and destroy 3–10 times more ozone than CFCs do (WRI 1998). Several countries with economies in transition, such as Poland, Russia, and Ukraine, are finding it difficult to comply with the phase-out schedule of the Montreal Protocol due to economic problems. Illegal trade in CFCs has also increased due to the perverse incentives provided by low production costs and high taxes.

The Indian scenario

In 1991, India's per capita consumption of ODS was less than 10 g, far below the level (300 g) permitted by the Montreal Protocol for developing

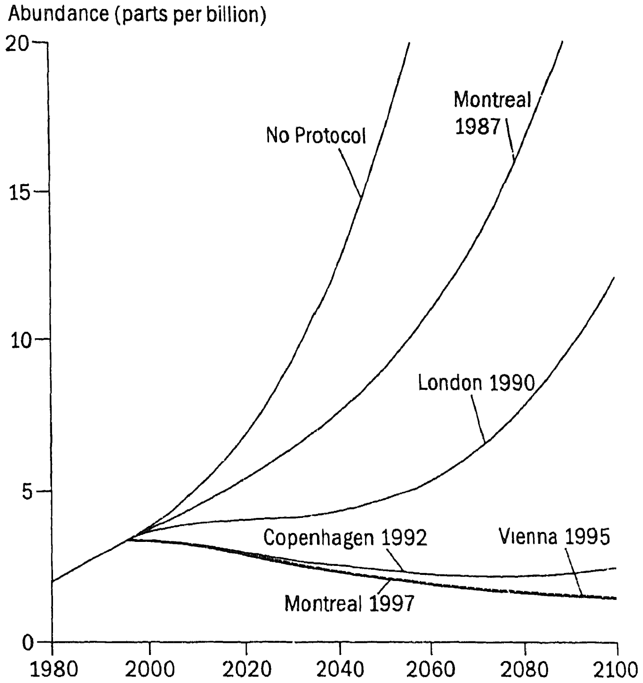


Figure 4 Projection of ozone losses with and without the Montreal Protocol

Source UNEP (2000)

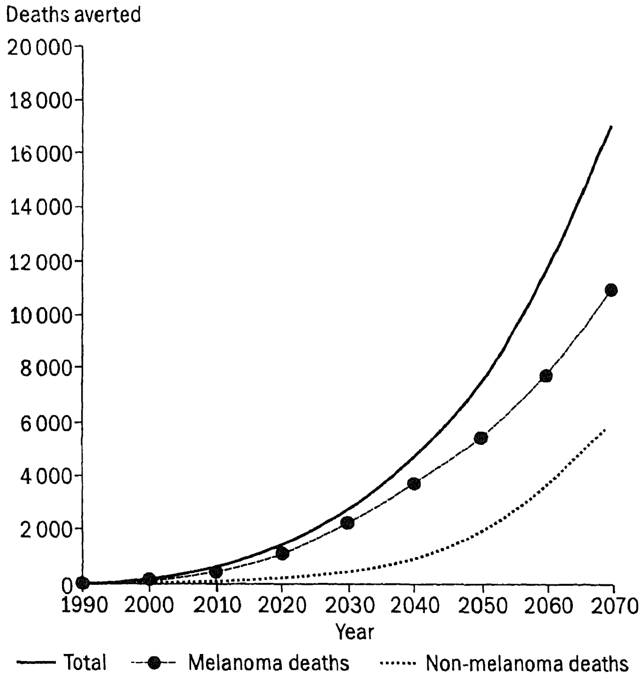


Figure 5 Projections: annual deaths from melanoma and non-melanoma skin cancer averted due to Montreal Protocol

Source UNEP (2000)

countries. India's consumption of ODS in 1991 was about 10 370 tonnes; of this, about 85% was produced domestically and 15% was imported. In terms of ODP (ozone-depleting potential), the total consumption was 13 111 tonnes, mostly in sectors that produce and consume essential goods and services. The maximum consumption was of carbon tetrachloride, followed by CFC-12 (GoI 1993). Table II gives the present substancewise break-up of ODS consumption.

India acceded to the Montreal Protocol along with its London Amendment on 19 June 1992. The India Country Programme for the phase-out of ODS under the Montreal Protocol was approved in November 1993. The projections for unconstrained ODS consumption were made in 1993, based on the development plans of each sector using these substances. These have been estimated to be around 184 200 tonnes in 2010. In terms of ODP, the unconstrained demand in 2010 will be 199 308 tonnes (GoI 1993) (Figure 6). Table 4.67 gives the projected phase-out of ODS production by 2010 as given in the India Country Programme.

Table II ODS (ozone-depleting substances) consumption in India

ODS	*Quantity* (tonnes)	*Year*
CFC-11	6 167	1999
CFC-12	2 050	1999
Halon-1211	106	1999
Halon-1301	47	1999
Carbon tetrachloride	14 635	1999
Methyl chloroform	1 415	1996
Methyl bromide	6.64	1999
HCFC-22	8 000	1998

Source UNEP (2001)

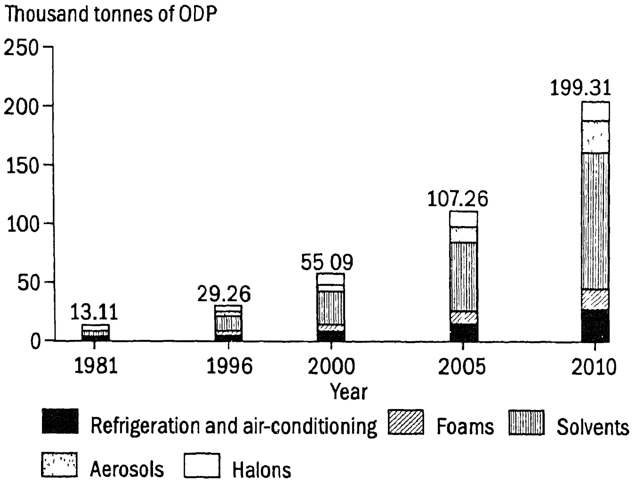


Figure 6 Estimated unconstrained ODP (ozone depleting potential) demand by sector up to 2010
Source GoI (1993)

The MoEF (Ministry of Environment and Forests) has established the Ozone Cell and the Steering Committee on the Montreal Protocol to facilitate implementation of the objectives of the India Country Programme. Various projects in the five ODS consuming sectors, namely aerosols, foams, halons, RAC (refrigeration, and air-conditioning), and solvents, have been submitted to the Multilateral Fund for seeking assistance for a changeover to ozone-friendly substitutes. Till date, 276 projects having a total grant amount of approximately 93 million dollars have been approved, which also includes a project on the phase-out of production of CFCs by domestic producers. The largest number of projects is in the foams sector, followed by RAC and aerosols. Research worldwide has yielded a large number of alternative chemicals that can be used as replacements for CFCs and other ODS. The technological options being looked at by the Indian industry vary with the end-use application. For example, in the RAC sector, HFC-134a and hydrocarbons are being looked at as alternative refrigerants and cyclopentane as an alternative foam blowing agent for insulation. In the aerosols sector, HAP (hydrocarbon aerosol propellant) has been the preferred choice; in the foams sector, HCFC-141b and other CFC-free technological options have been adopted. The available choices in the solvents and halons sector vary widely depending on the specific application.

To meet India's commitments under the Montreal Protocol, the Government of India has also taken certain major policy decisions.

- Goods required to implement ODS phase-out projects funded by the Multilateral Fund are fully exempt from payment of duties. This benefit has also been extended to new investments with non-ODS technologies.
- Commercial banks are prohibited to finance or refinance investments with ODS technologies.

Rules for the formal regulation of ODS phase-out have been notified in the Gazette of India on 19 July 2000 and are called Ozone Depleting Substances (Regulation and Control) Rules, 2000. They were notified under the Environment (Protection) Act, 1986. These rules were drafted by the MoEF following consultations with industries and related government departments. The rules pertain to regulation of production, consumption, import/export, sale, purchase, and use of ODS. The regulation on production and consumption of ODS puts quantitative restrictions on their production and allows the central government to introduce a quota system to regulate implementation. The rules limit the use of ODS by enterprises engaged in various activities after specified dates. The details of such activities and the corresponding phase-out dates are given in Schedule IV and V of the rules. The export and import of ODS is allowed only with countries specified in Schedule VI of the notification. Moreover, a license is required for export and import of ODS. There is also a prohibition on new investments with ODS.

During 2000, the Multilateral Fund approved 35 investment and 11 non-investment projects for India worth about 10.8 million dollars which will phase-out 9158 ODP tonnes when completed. India is also unique amongst the Article 5 countries as it is one of the few developing countries that has a well established CFC production set-up. The phase-out strategy for the production of CFCs and other ODS was prepared and is presently under implementation.

Climate change

The earth's atmosphere plays a critical role in regulating the heat balance of the planet. It allows incoming short-wave solar radiation to pass through relatively unimpeded. However, the long-wave terrestrial radiation emitted by the earth's surface is partially absorbed and then re-emitted by a number of trace gases in the atmosphere, which are known as GHGs (greenhouse gases). The main GHGs include water vapour, CO_2, methane, CFCs, nitrous oxide, and ozone. This natural 'greenhouse effect' keeps the earth warmer by about 33 °C and is vital for the existence of life. Human activities are increasing the concentrations of naturally existing GHGs and adding new ones such as CFCs. This enhanced greenhouse effect causes an increase in global temperatures, which can be amplified through positive feedbacks such as increase in water vapour, or reduced through negative feedbacks such as increase in stratospheric aerosols. The sum of all these potential changes is referred to as climate change.

The IPCC (Intergovernmental Panel on Climate Change) in its Third Assessment Report (IPCC Secretariat 2001) has confirmed that the evidence for human interference in the climate is stronger than ever. The atmospheric concentrations of CO_2, methane, and nitrous oxide have grown by about 31%, 151%, and 17%, respectively, over the period 1750–2000 (IPCC Secretariat 2001). Specifically, CO_2 concentrations have increased from about 280 PPMV (parts per million volume) in pre-industrial times to 360 PPMV in 2000 (Figure 7). At the same time, mean global surface temperature has increased by 0.6 °C (±0.2 °C) over the 20th century, with the 1990s being the warmest decade since 1860, i.e. the period of instrumental record (Figure 8). Table 4.68 traces recent trends in atmospheric CO_2 concentrations and global average temperatures.

Each GHG has a different capacity to cause global warming. This 'global warming potential' or GWP depends on the lifetime of the gas, the amount of extra infrared radiation it will absorb, and its density. Table 4.69 provides data on the main characteristics of major GHGs. On accounting for GWP and estimated global emissions, CO_2 will be responsible for about

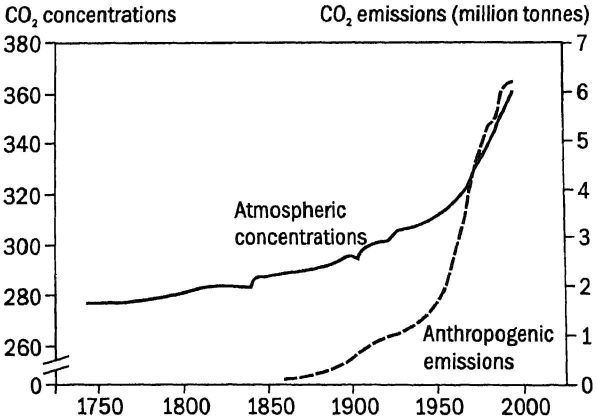


Figure 7 Trends in atmospheric concentrations and anthropogenic emissions of CO_2 (carbon dioxide)
Source ORNL (1994)

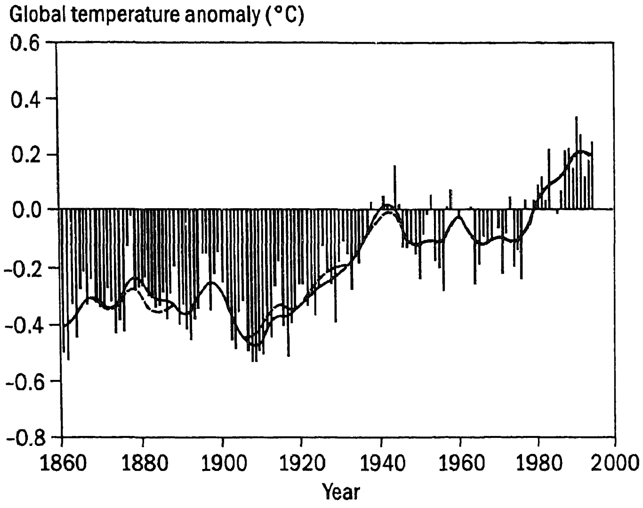
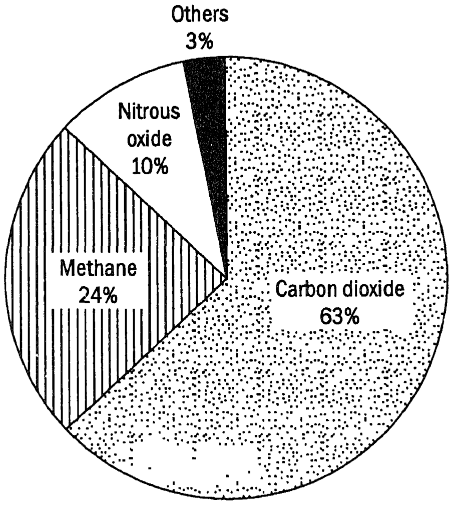


Figure 8 Combined land surface, air, and sea surface temperatures (°C): 1861 to 1994 relative to 1961 to 1990 (The solid curve represents smoothing of the annual values shown by the bars to suppress sub-decadal time-scale variations. The dashed smoothed curve is the corresponding result from IPCC [1992].)
Source IPCC Secretariat (1996)

two-thirds of the warming effect over the next 100 years (Figure 9).

The IPCC Secretariat (1996) used a range of scenarios (IS92a–f) of future GHG and aerosol precursor emissions based on assumptions of population and economic growth, land-use, technological changes, energy availability, and fuel mix over the period 1990–2100. Based on these scenarios, it predicted that by 2100, the global mean temperature will increase by 1.0–3.5 °C (with a best estimate of 2.5 °C). This global warming will lead to accelerated sea level rise due to thermal expansion of oceans, melting of glaciers and small ice caps, melting of the Greenland ice sheet, and break-up of the Antarctic ice sheet (CGER 2000).



Note Tropospheric ozone not included
Figure 9 Relative warming of current emissions of greenhouse gases over next 100 years

The IPCC Secretariat (1996) predicts that the global mean sea level will rise by 13–94 cm (with a best estimate of 50 cm).[2] This projected rise is 2–5 times faster than the rate observed over the last 100 years. The projections on temperature and sea level rise for different emission scenarios are illustrated in Figures 10 and 11.

The Third Assessment Report of the IPCC has constructed a new set of policy scenarios that incorporate more fully the effects of policies for sulphur dioxide (SO_2) reduction. These are known as the SRES (Special Report on Emission Scenarios) A1, A2, B1, and B2 scenarios. The SRES scenarios are based on a set of 'storylines' that define parameters such as future population, economic growth, energy technologies, and international cooperation[3] (Wigley 1999). Table 4.70 presents projections of anthropogenic emissions of CO_2 and SO_2 for 2100 compared with those in 1990. Projections based on the SRES scenarios estimate a higher rate of warming (1.4 °C–5.8 °C)

---

[2] For any given region, however, what is relevant is not this eustatic (or worldwide) sea-level rise but the relative sea-level rise. This is the difference between the eustatic rise and any change in local elevation, brought about by subsidence or compaction, regional differences in heating, and circulation patterns

[3] A1 is a future world with rapid economic growth and rapid introduction of new and more efficient technology, low population growth and a substantial reduction in regional differences in per capita income. A2 corresponds to a very heterogenous world with high population growth and less concern for rapid economic and technological development. B1 has low population growth, embraces rapid changes in economic structures, a move towards a less materialistic society, the introduction of clean technologies, rapid technology development, and an emphasis on global solutions. B2 has moderate population growth, less rapid but more diverse technological change, and an emphasis on local solutions and environmental sustainability.

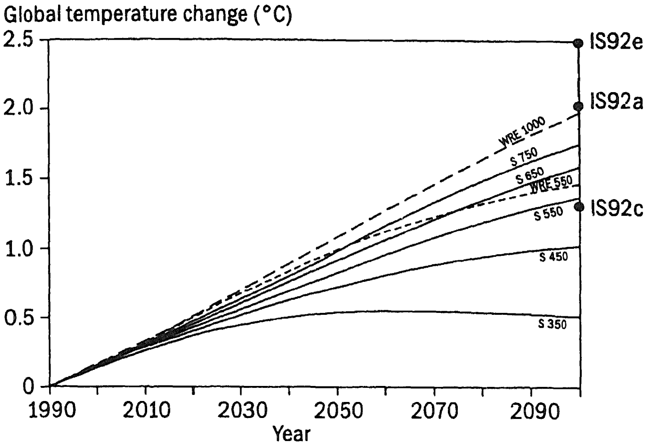


Figure 10 Projected global mean temperature change relative to 1990-levels for various greenhouse gas stabilization scenarios
Source IPCC Secretariat (1997)

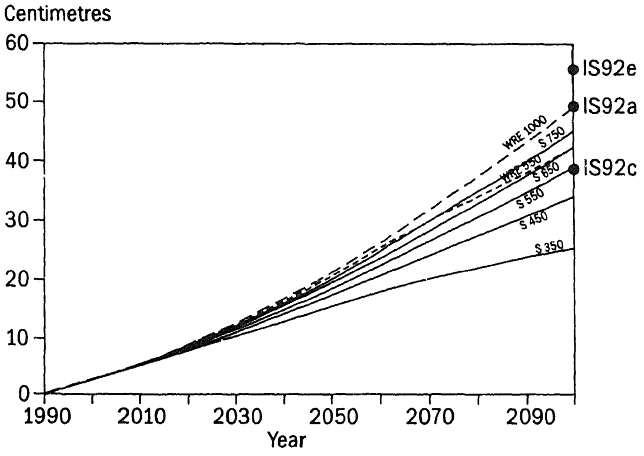


Figure 11 Projected global sea-level change relative to 1990 levels for various greenhouse gas stabilization scenarios
Source IPCC Secretariat (1997)

over the period 1990–2100, while sea level is projected to rise by 9–88 cm (IPCC Secretariat 2001). Figures 12 and 13 show the projections corresponding to these SRES scenarios.

Impacts of climate change

Changes in surface air temperature and sea level can change precipitation quantity and pattern, vegetation cover, and soil moisture. The impact on natural and managed systems will depend critically on the rate of climate change. The

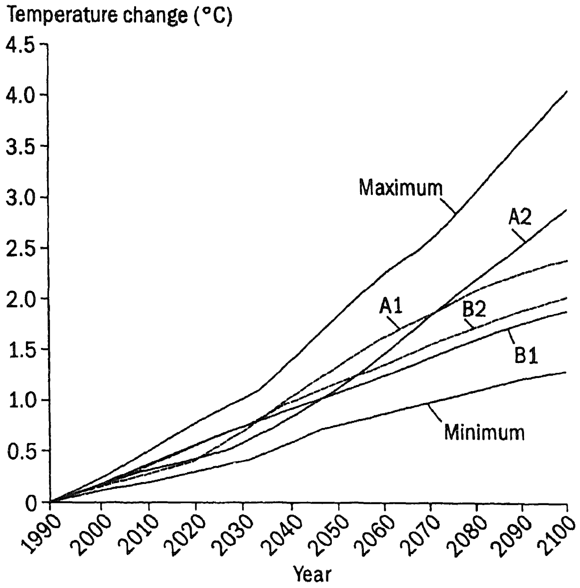


Figure 12 Central temperature estimates plus extremes for the preliminary Special Report on Emission Scenarios
Source Wigley (1999)

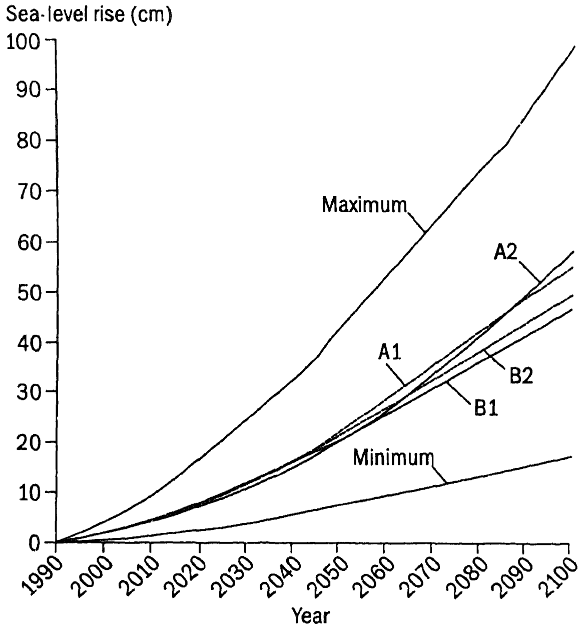


Figure 13 Central sea-level rise estimates plus extremes for the preliminary Special Report on Emission Scenarios
Source Wigley (1999)

predicted changes in global temperature are greater than any seen in the last 10 000 years. Further, regional temperature changes can be substantially different from the global average and the frequency, intensity, and duration of storms and other extreme weather events can increase.

With unmitigated emissions, substantial dieback of tropical forests and grasslands is predicted to occur by the 2080s, particularly in parts of South America and Africa. There could be large decreases in the availability of water from rivers in Australia, India, southern Africa, South America, Europe, and the Middle East (Figure 14). As a consequence of climate change, cereal yields in Africa, the Middle East, and India are expected to decline (Figure 15). GHG-induced sea-level rise can have a number of physical impacts on coastal areas, including loss of land due to inundation and erosion, increased flooding, and salt-water intrusion. These could adversely affect coastal agriculture, tourism, freshwater resources, fisheries and aquaculture, human settlements, and health (IPCC Secretariat 1996). There can also be significant impacts on human health, due to the increased incidences of heat stresses, malaria, and other vector-borne and water-borne diseases (DETR 1999). Tables 4.71 and 4.72 provide estimates of monetary damages to different sectors and regions as a result of climate change associated with a doubling of CO_2 concentrations over pre-industrial levels. Developing countries such as India are more vulnerable to the effects of climate change due to their high dependence on climate-sensitive sectors such as agriculture and forestry, and their low technical and financial adaptive capacity.

Agriculture

Global circulation models indicate that India's climate can become warmer under conditions of increased atmospheric CO_2 (Lonergan 1998). It is also likely that there will be an increase in the frequency of heavy rainfall events in South and Southeast Asia (IPCC Secretariat 1998). Agricultural productivity is sensitive to two broad classes of climate-induced effects: (1) direct effects from changes in temperature, precipitation, or CO_2 concentrations and (2) indirect effects through changes in soils, distribution, and frequency of infestation by pests, insects, diseases, or weeds. Rice and wheat yields can decline considerably with climatic changes (Seshu and Cady 1984; Sinha 1989; Sinha and Swaminathan 1991; Achanta 1993; Rao and Sinha 1994; Aggarawal and Sinha 1994; Lal, Singh, Rathore, et al. 1996). However, the vulnerability of agricultural production to climate change depends not only on the physiological response of the affected plant, but also on the ability of the affected socio-economic systems of production to cope with changes in yield, and to changes in the frequency of droughts or floods. The adaptability of farmers in India is severely restricted by the heavy reliance on natural factors and the lack of complementary inputs and institutional support systems.

Kumar and Parikh (1998) estimate that even after accounting for farm-level adaptation, the loss in farm-level net revenue will range between 9% and 25% for a temperature rise of 2 °C–3.5 °C. Sanghi, Mendelsohn, and Dinar (1998) calculate that a 2 °C rise in mean temperature and a 7% increase in mean precipitation will reduce net revenues by 12.3% for the country as a whole. Agriculture in the coastal regions of Gujarat, Karnataka, and Maharashtra is found to be the most negatively affected. Small losses are also indicated for the major foodgrain producing regions of Haryana, Punjab, and western Uttar Pradesh; on the other hand, Andhra Pradesh, Orissa, and West Bengal are predicted to benefit to a small extent from warming.

Forests

Increased temperature and rainfall can result in increased productivity of tropical forests in India, migration of forest types to higher elevations, and transformation of drier forest types to moister types (Ravindranath and Sukumar 1998). Achanta and Kanetkar (1996) estimate that decline in soil moisture as a result of higher temperatures[4] will reduce teak productivity from 5.40 m^3/ha to 5.07 m^3/ha. The study also showed that the productivity of moist deciduous forests can decline from 1.8 m^3/ha to 1.5 m^3/ha. Such climate-induced changes in productivity and configuration of forest ecosystems can have profound implications for traditional livelihood, industry, biodiversity, soil and water resources, and hence, agriculture.

Coastal areas

India has a low-lying densely populated coastline extending about 6500 km. The UNEP (1989) identified India among the 27 countries that are

---

[4] Under climate scenarios generated by the ECHAM 3 model.

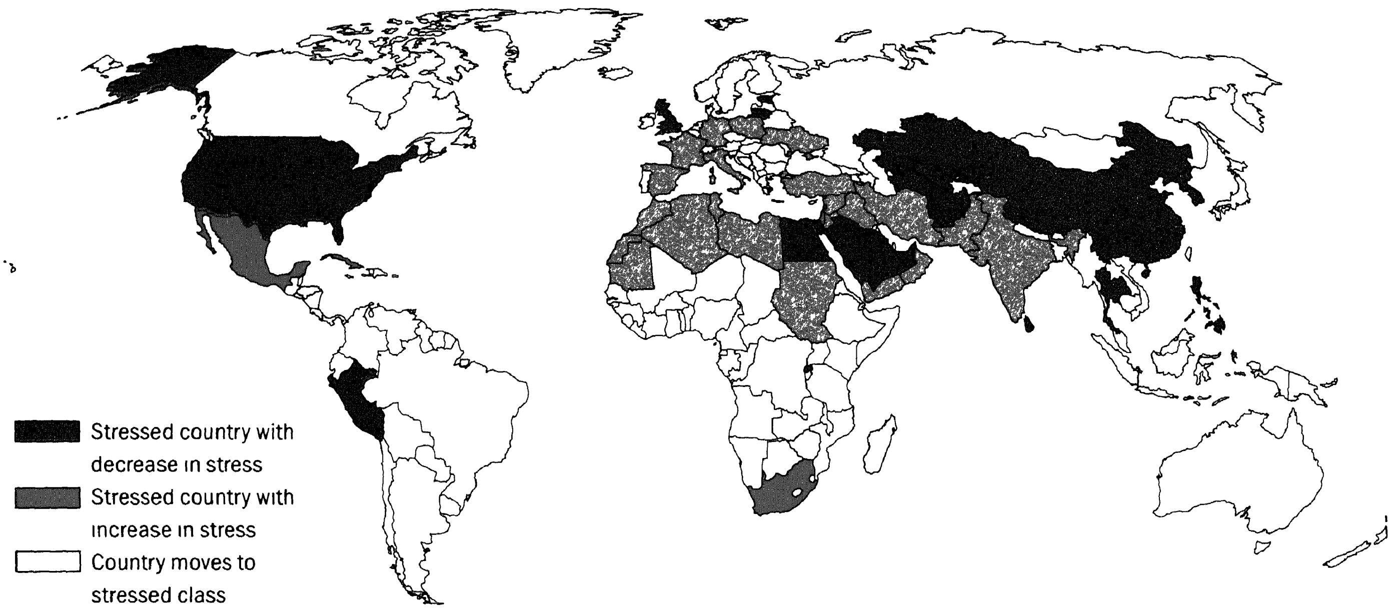

■ Stressed country with decrease in stress
▨ Stressed country with increase in stress
☐ Country moves to stressed class

Figure 14 Changes in water stress by the 2080s with unmitigated emissions
Source DETR (1999)

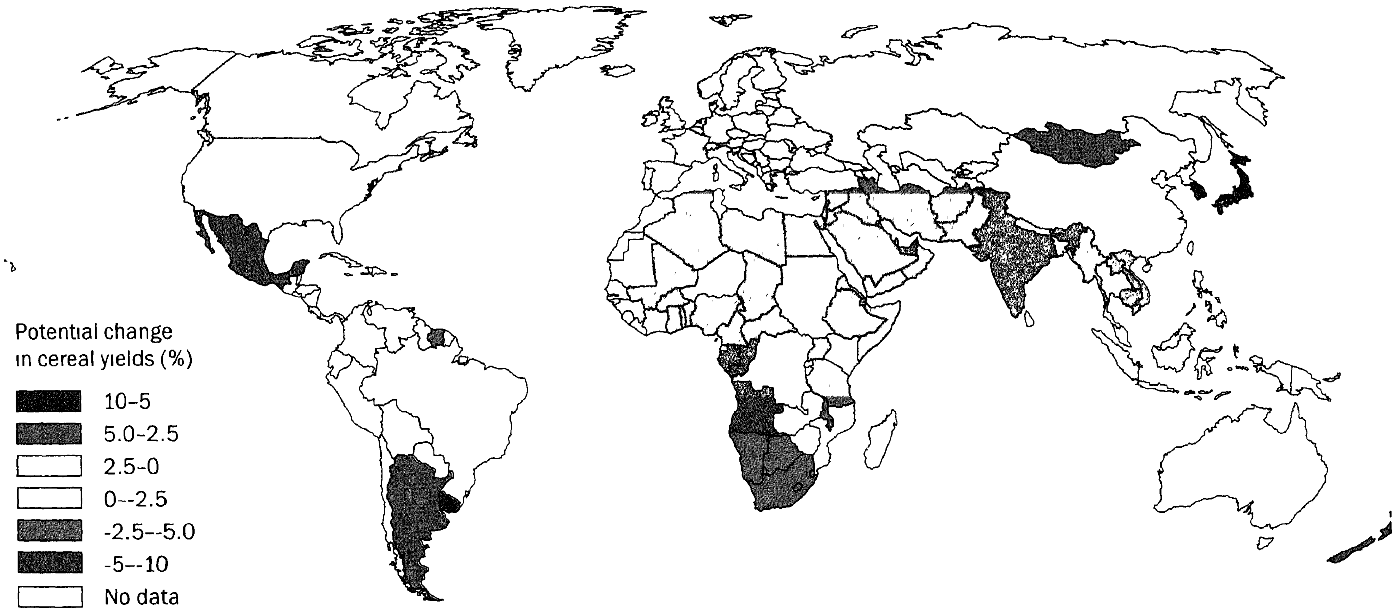


Figure 15 Changes in crop yield by the 2080s with unmitigated emissions
Source DETR (1999)

most vulnerable to sea-level rise. Most of the coastal regions are agriculturally fertile, with paddy fields that are highly vulnerable to inundation and salinization. Coastal infrastructure, tourist activities, and onshore oil exploration are also at risk. The impacts of any increase in the frequency and intensity of extreme events, such as storm surges, can be disproportionately large, not just in heavily developed coastal areas, but also in terms of the paralyzing devastation in low-income rural areas. The 1999 tropical cyclone that hit Orissa resulted in a death toll of about 10 000 and demonstrates the extreme significance of impacts related to climate variability.

In a case study of Orissa and West Bengal (IPCC Secretariat 1992), it was estimated that in the absence of protection, a 1-m sea-level rise would inundate 1700 km^2 of prime agricultural land. Asthana (1994) showed that in the absence of protection, a 1-m sea-level rise on the Indian coastline is likely to affect a total area of 5763 km^2 and put 7.1 million people at risk. The dominant cost, as indicated in Table 4.73, is land loss, which accounts for 83% of all damages. The extent of vulnerability, however, depends not only on physical exposure but also on the level of economic activity in the region. TERI (1996) provided a district-level ranking[5] of vulnerability to 1-m sea-level rise by constructing a weighted index. The study also assessed the economic implications of such a rise on the most and least vulnerable districts in order to provide the range of projected economic impacts on the Indian coast. In terms of present value, the results range from 2287 billion rupees for Mumbai to 3.6 billion rupees for Balasore. Table 4.74 gives the cost of protection and value of anticipation of sea-level rise for these representative districts.

Sources and sinks of greenhouse gases

Greenhouse gas emissions occur during most economically important activities. The main reasons for the increase in atmospheric CO$_2$ are the use of fossil fuels in energy combustion, transport, and industrial processes, and changing land-use patterns. Methane emissions come from livestock, animal waste, coal-bed releases, oil and gas production and transportation, wet rice cultivation, biomass burning, landfills, and other human waste. Sources of nitrogen oxides are fertilizer use, fossil fuel combustion, and nylon manufacture (Fuglesvedt, Hanisch, Isaksen, et al. 1994). The relative contribution of different sectors to the change in radiative forcing over 1980–90 is shown in Figure 16. Tables 4.75 and 4.76 trace the trends in the growth of CO$_2$ emissions from different sectors, both at the global level and specifically for India.

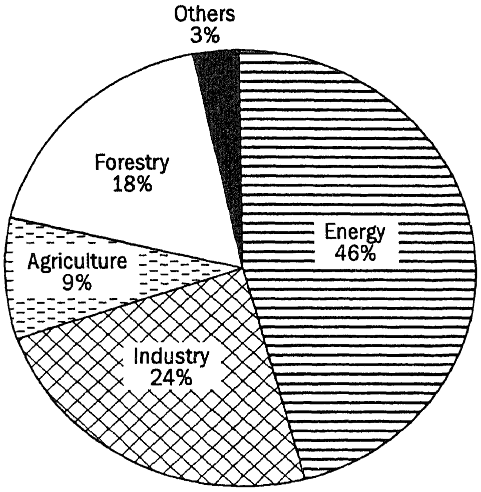


Figure 16 Contribution of different sectors to change in radiative forcing (1980–90)
Source IPCC Secretariat (1990)

There are also a number of natural sinks for GHGs. The ocean is the largest current and potential sink for CO$_2$. It contains about 40 000 GtC (gigatonnes of carbon) compared with 750 GtC in the atmosphere and 2200 GtC in the terrestrial biosphere (IPCC Secretariat 1996). Vegetation and soils also have the capacity to sequester CO$_2$. The major sink for atmospheric methane, on the other hand, is its oxidation by OH (hydroxyl) in the troposphere. Soils may also provide a removal mechanism for methane. Tables 4.78 and 4.79 provide details on sources and sinks of CO$_2$ and methane.

In India, total CO$_2$ equivalent emissions in 1990 were 1 001 352 Gg, which was approximately three per cent of total global emissions. In terms of individual sectors, the energy sector was the largest emitter of CO$_2$, contributing 55% of the national emissions. These include emissions from road transport, burning of traditional biomass fuels, coal mining, and fugitive emissions from oil and natural gas. Industrial processes, primarily in the cement industry, also release CO_2. Agriculture is the second largest source of GHGs in India. Methane emissions from enteric fermentation in domestic animals, manure management, rice cultivation, and burning of agricultural residues constitute 34% of national GHG emissions. The net CO_2 uptake and emissions from the land-use change and forestry sector were almost equal, resulting in negligible emissions from this sector (ADB-GEF-UNDP 1998). The national GHG inventory for India is presented in Table 4.80.

---

[5] The weighted average used three parameters at the district level: share of land affected in total area, share of population affected in total population, and the Centre for Monitoring Indian Economy index of relative development.

North-South contributions to climate change

Climate change is primarily influenced by the total stock of GHGs in the atmosphere and not by annual GHG emissions. Historically, the developed countries have been responsible for more than 75% of the total global stock of GHGs. Figure 17 shows the contributions of industrialized countries, developing countries, and countries of the former Eastern Bloc to carbon emissions from fossil fuel burning during 1950–1997.

The geographical distribution of GHG emissions is not uniform (Table 4.77). In terms of annual contributions, the level of emissions from fuel combustion across different countries shows considerable variation in terms of absolute amounts (Figure 18) and per capita emissions (Figure 19). Although India figures among the top 10 contributors to GHG emissions (Table 4.81), its relative share in terms of per capita emissions is only one-sixth of the world average

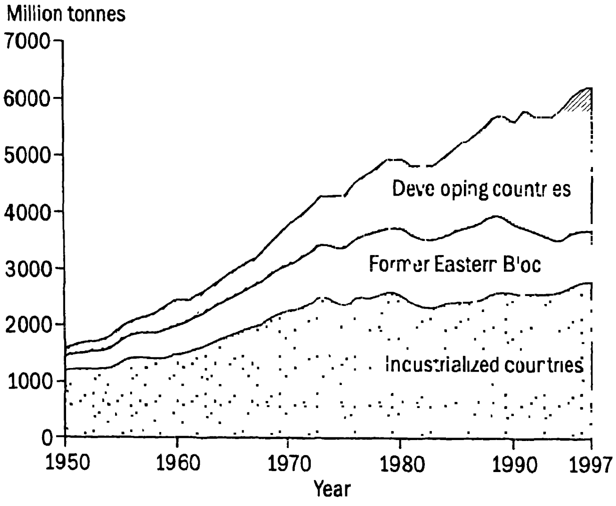
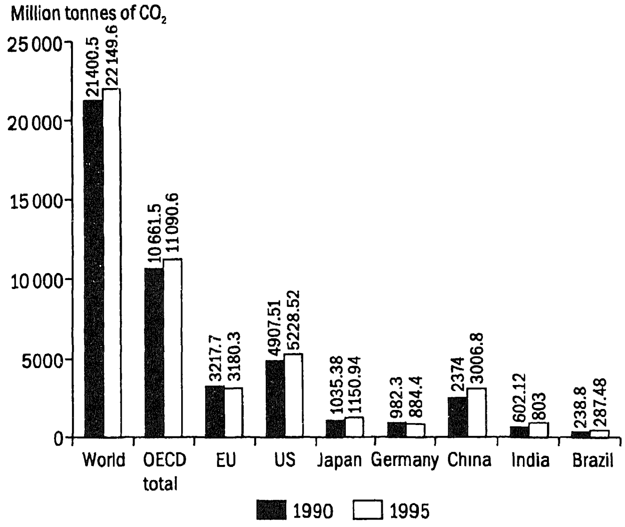
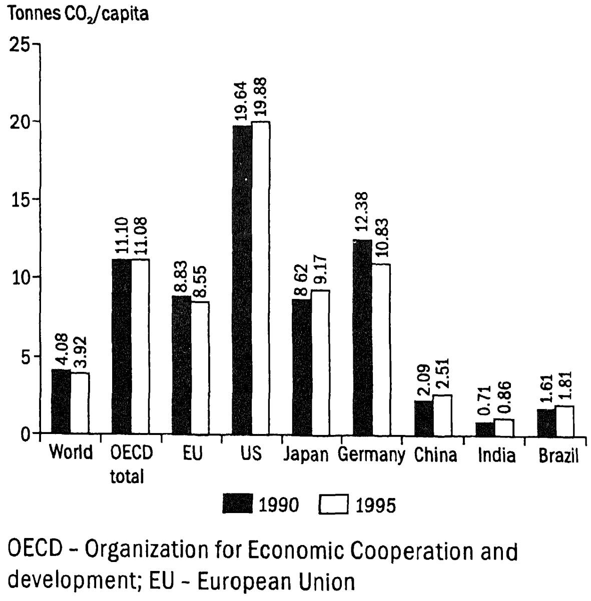


Figure 17 Carbon emissions from fossil fuel burning: 1950-97
Source Dunn (1998)



OECD - Organization for Economic Cooperation and development; EU - European Union

Figure 18 Total CO_2 (carbon dioxide) emissions from fuel combustion
Source TERI (1999)



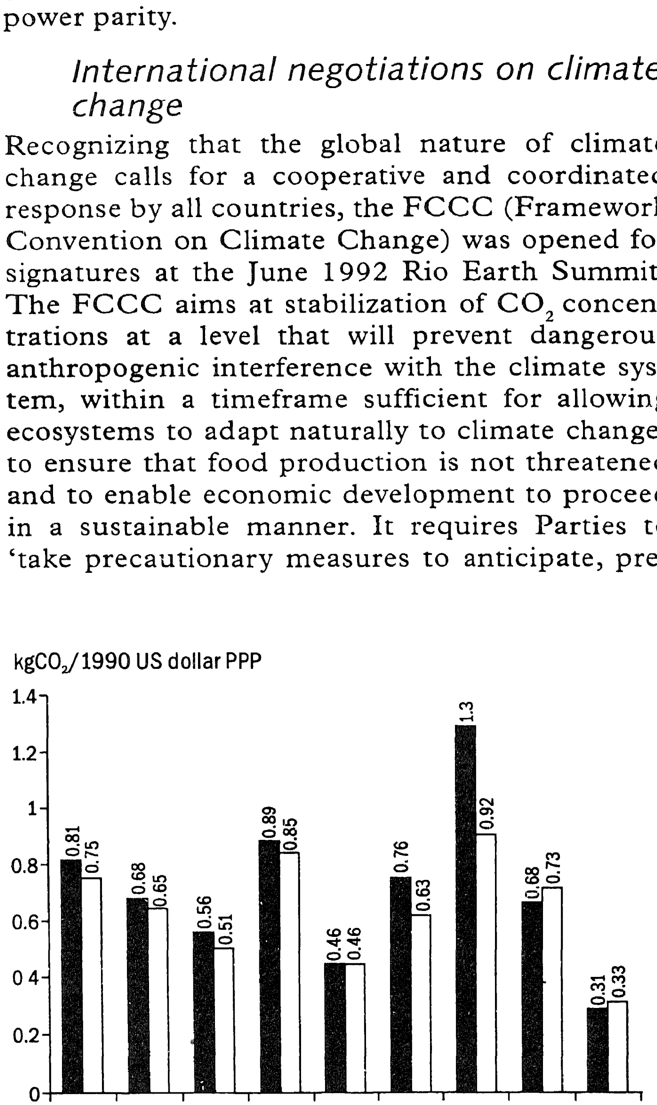
OECD - Organization for Economic Cooperation and development; EU - European Union
Note CO_2 from fuel combustion

Figure 19 Per capita CO_2 (carbon dioxide) emissions
Source TERI (1999)

(ADB 1994). The per capita CO_2 equivalent emissions for India in 1990 are estimated to be 1.194 tonnes or 325 kg of carbon (ADB–GEF–UNDP 1998). In comparison, the per capita emissions for Japan and the US are 2400 kg and 5400 kg of carbon, respectively. Table 4.82 provides an international comparison of per capita CO_2 emissions from fossil fuel combustion for 1997. Figure 20 shows CO_2 intensity in terms of gross domestic product valued at purchasing power parity.

International negotiations on climate change

Recognizing that the global nature of climate change calls for a cooperative and coordinated response by all countries, the FCCC (Framework Convention on Climate Change) was opened for signatures at the June 1992 Rio Earth Summit. The FCCC aims at stabilization of CO_2 concentrations at a level that will prevent dangerous anthropogenic interference with the climate system, within a timeframe sufficient for allowing ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. It requires Parties to 'take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse impacts. Where there are threats of irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures' (FCCC Secretariat 1992). Recognizing that developed countries are historically responsible for climate change and also possess the financial and technical resources to tackle this problem, the FCCC emphasized the principles of equity, respective capabilities, and the common but differentiated responsibilities of countries at different levels of development. The FCCC entered into force on 21 March 1994 and had been ratified by 186 countries as of May 2001.



PPP - purchasing power parity; OECD - Organization for Economic Cooperation and development; EU - European Union
Note CO_2 from fuel combustion
Figure 20 CO_2 (carbon dioxide) intensity
Source TERI (1999)

Subsequently, the Parties to the FCCC adopted the Kyoto Protocol on 11 December 1997. Annex I Parties (developed countries) agreed to reduce their overall emissions of six GHGs by at least five per cent below the 1990 levels between 2008 and 2012 (Table 4.83). The Protocol also established emissions trading and 'joint implementation' between developed countries and a CDM ('clean development mechanism') to encourage joint emissions reduction projects between developed and developing countries. The main features of the Kyoto Protocol are listed in Box 1.

CDM has been conceived as an international instrument to reduce the overall cost of GHG mitigation, while also promoting sustainable development in developing countries. It allows Annex I countries to invest in low-cost abatement opportunities in developing countries and to receive credit for the resulting emissions reductions. These credits can then be used towards meeting their targets under the Kyoto Protocol.

In November 1998, 160 Parties to the FCCC adopted the Buenos Aires Plan of Action to set a 2-year deadline to strengthen the implementation of the FCCC and to facilitate the operationalization of the Kyoto Protocol. The Buenos Aires Plan of Action formed the basis for the agenda at CoP-5 held in November 1999 at Bonn. In CoP-5, an aggressive timetable was set to achieve measurable progress by CoP-6 on the entry into force of the Kyoto Protocol.

Recent developments

The CoP-6 was held at The Hague in November 2000. This conference was supposed to mark the culmination of efforts to implement the Kyoto Protocol. Despite high expectations, the

Box 1 Main features of the Kyoto Protocol

- Six major GHGs covered—carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride.
- Annex I Parties will reduce their overall emissions to 5.2% below 1990 levels by the first commitment period (2008-12), with differentiated targets for various parties (Table 4.84).
- Annex I Parties can use net changes in GHG emissions resulting from human-induced land-use change and forestry activities, limited to afforestation, reforestation, and deforestation since 1990, to meet their commitments.
- Annex I Parties that have agreed to jointly fulfil their commitments are allowed to do so by setting out their respective emission levels in agreement. This is known as the bubble concept.
- Annex I Parties can carry forward the excess of the assigned amount over emissions from one commitment period to another.
- Three instruments (now known as the Kyoto mechanisms) were introduced to enable Annex I countries to achieve their targets in a flexible and cooperative manner. These are ET (emissions trading), JI (joint implementation), and CDM (clean development mechanism).

Source TERI (1998)

conference could not achieve a tangible result due to the lack of consensus on a range of such key issues as

- the extent to which the use of flexibility mechanisms should supplement domestic action by Annex I Parties,
- the use of sinks domestically and in the flexibility mechanisms, and
- the consequences of non-compliance with GHG reduction targets.

Last-minute negotiations between the US and EU collapsed, and it was agreed to suspend CoP-6 and to resume discussions in July 2001 in Bonn.

To enter into force, the Protocol needs to be ratified by 55 states, including Annex I Parties representing at least 55% of total CO_2 emissions of Annex I Parties in 1990. As of 9 May 2001, 34 countries had ratified the Protocol, of which only one is an Annex I Party (Romania, which accounts for 1.2% of 1990 Annex I emissions). On the eve of the critical round of talks in Bonn, the US, which itself accounted for 36% of Annex I emissions in 1990, declared that it would not ratify the Protocol. President George W Bush argued that the Kyoto Protocol itself is 'fatally flawed' as it exempts developing countries such as India from any GHG reduction commitments, and stated his unwillingness to undertake any agreement that would have adverse effects on the American economy.

In the resumed session of CoP-6 at Bonn, ministers and senior government officials approved a political agreement on core elements of the Buenos Aires Plan of Action that would help move towards the adoption of the Kyoto Protocol. This 'Bonn agreement' represents a compromise on such key issues as funding under the Convention and Protocol, technology transfer, adverse impacts of climate change and response measures, flexibility mechanisms, sinks, and compliance.

Key features of the Bonn agreement include

- establishment of LDC (least developed countries) fund, in addition to the special climate change fund and adaptation fund;
- Annex I Parties should provide funding to developing countries through these funds, increased GEF replenishment, and bilateral and multilateral channels;
- formation of an expert group on technology transfer;
- activities for adaptation to climate change impacts to be supported through the GEF, special climate change fund, and other bilateral and multilateral sources, apart from the Adaptation Fund;
- domestic action in Annex I countries to be 'conducive to narrowing per capita differences' in emissions between developed and developing countries;
- domestic action to constitute a 'significant' element in Annex I Parties' efforts to meet their Kyoto commitments;

- two per cent of the share of proceeds from CDM projects to contribute towards the adaptation fund;
- Annex I Parties to refrain from having nuclear projects under the CDM and JI;
- prompt start for the CDM and simplified procedures (fast-track approach) for defined small-scale CDM projects;
- establishment of a supervisory committee for verification of (Track II) JI projects;
- specification of a commitment period reserve to be maintained for emissions trading;
- afforestation and reforestation projects to be eligible under the CDM in the first commitment period, subject to a cap of one per cent of base year emissions, multiplied by five;
- forest management, crop land management, grazing land management, and revegetation to be eligible as additional sinks activities for domestic efforts, subject to a cap and discount factor; and
- non-compliance provisions include deduction (from the second commitment period assigned amount) of 1.3 times the excess emissions in the first commitment period, and suspension of eligibility to participate in international emissions trading.

The Bonn agreement served as the basis for negotiations at CoP-7 in Marrakesh, Morocco, from 29 October–10 November 2001. All parties agreed upon a package deal finalizing the operational details for implementing the Kyoto Protocol. Key elements include

- creation of a new removal unit for sinks activities;
- limited banking of CDM and JI credits;
- reporting and compliance requirements for using the flexibility mechanisms;
- increase in Russia's allowance for forest management credits; and
- acceptance of Kazakhstan as an Annex I party in the Kyoto Protocol.

The Indian scenario

India signed the FCCC on 10 June 1992 and ratified it on 1 November 1993 (ADB–GEF–UNDP 1998). Although it does not have GHG reduction targets, it has actively taken steps to address the climate change issue. The MoEF has constituted a 'Working Group on the FCCC' to deliberate upon measures and positions that should be taken regarding the various issues emerging from the climate change negotiations. A separate group on the Kyoto mechanisms has also been constituted. The MoEF has also been supporting a number of programmes and projects at the regional and national levels, which will have a mitigating impact on GHG emissions. Table 4.84 lists potential mitigation options that have been identified for various sectors in India, along with their costs.

Other developments include

- participation of India in the Fourth SAARC Environment Ministers Conference held in Colombo, Sri Lanka, from 30 October–1 November 1998, which formulated a common SAARC (South Asian Association for Regional Cooperation) position to be adopted at CoP-4;
- the Indo-US joint statement on Cooperation in Energy and Related Environmental Aspects was signed in October 1999, whereby India and the US agreed to work together towards early agreement on the elements of the Kyoto mechanisms; and
- the Joint Statement on Cooperation in Energy and Environment between India and the US was signed on 22 March 2000. This declared India's intention to achieve a 10% share of renewable energy in electricity capacity additions by 2012 and a 15% improvement in energy efficiency by 2007/08. Further, a Joint Consultative Group on Clean Energy and Environment will be created to foster greater bilateral cooperation, government-to-government dialogue, and public and private sector cooperation.

The GEF acts as the interim financing mechanism of the FCCC and helps fund the additional or incremental cost of efforts to address global environmental objectives, which are beyond those required for national sustainable development. Table 4.85 provides details of climate-change-related GEF projects in India.

The Government of India has declared its support of the CDM in a cabinet decision prior to CoP-6. It is also actively identifying priority CDM projects related to power and renewable energy in India. The government has also started work on the first National Communication to the UNFCCC. Currently, one AIJ (activities implemented jointly) project is operational in India, and four others have been approved (Table 4.86).

References

Abramovitz A. 1996
Imperiled waters, impoverished futures: the decline of freshwater ecosystems, p. 59
Washington, DC: World Watch Institute
[World Watch paper No. 128.]

Achanta A N. 1993
An assessment of the potential impact of global warming on Indian rice production
In *The Climate Change Agenda: an Indian perspective,* edited by A N Achanta
New Delhi: Tata Energy Research Institute. 305 pp.

Achanta A N and Kanetkar R. 1996
Impact of climate change on forest productivity: a case study of Kerala, India
Paper presented at the *Asian and Pacific Workshop on Climate Change Vulnerability and Adaptation Assessment,* 15–19 January 1996, Manila, The Philippines.

ADB (Asian Development Bank). 1994
Climate Change in Asia: India Country Study
Manila: ADB

ADB–GEF–UNDP (Asian Development Bank–Global Environment Facility–United Nations Development Programme). 1998
Asia least-cost greenhouse gas abatement strategy: India
Manila: ADB

Aggarwal P K and Sinha S K. 1994
Effect of probable increase in carbon dioxide and temperature on wheat yields in India
Journal of Agricultural Meteorology **48**(5): 811–814

Asthana V. 1994
Impacts of greenhouse-induced sea level rise on the islands and coasts of India
New Delhi: Jawaharlal Nehru University.

Benedick R E. 1998
Ozone Diplomacy: new directions in safeguarding the planet
Cambridge: Harvard University Press.

Bruner A G, Gullison R E, Rice R E, and da Fonseca G A B. 2001
Effectiveness of parks in protecting tropical biodiversity
Science **291**: 125–127.

CBD (Convention on Biological Diversity) Secretariat. 2001
Secretariat of the CBD: United Nations Environment Programme
www.biodiv.org
(Accessed on 4 June 2001)

CGER (Center for Global Environmental Research). 2000
Data Book of Sea Level Rise 2000, edited by N Mimura and H Harasawa
Ibaraki, Japan: National Institute for Environmental Studies, Environment Agency of Japan.

DETR (Department of the Environment, Transport and the Regions). 1999
Climate Change and its Impacts: stabilization of carbon dioxide in the atmosphere
Brackuell, UK: Hadley Center for Climate Prediction and Research. 28 pp.

Dunn S. 1998
Dancing around the key climate issue: can the North and South get in step?
World Watch **11**(6): 19–27.

FCCC Secretariat. 1992
Framework Convention on Climate Change
Bonn: United Nations Framework Convention on Climate Change.

Fuglestvedt J, Hanisch T, Isaksen I, Selrod R, Strand J, Torvanger A. 1994
A review of country case studies on climate change
Washington, DC: Global Environment Facility

Gleick P H (ed.) . 1993
Water in Crisis: a guide to the world's freshwater resources
New York: Oxford University Press. 5 p.

GoI (Government of India). 1993
Country Programme: phase-out of ozone-depleting substances under the Montreal Protocol
New Delhi: GoI

Groombridge B and Jenkins M D. 2000.
Global Biodiversity: earth's living resources in the 21st century
UK: World Conservation Monitoring Centre. 246 pp.

IPCC (Inter-governmental Panel on Climate Change) Secretariat. 1990
Climate change: the IPCC response strategies
Cambridge: Cambridge University Press

IPCC (Inter-governmental Panel on Climate Change) Secretariat. 1992
Global climage change and the rising challenge of the sea
Geneva: World Meteorological Organization and United Nations Environment Programme
[Supporting document for the IPCC]

IPCC (Inter-governmental Panel on Climate Change) Secretariat. 1996
Climate change 1995: the science of climate change
Cambridge: Cambridge University Press: 572 pp.

IPCC (Inter-governmental Panel on Climate Change) Secretariat. 1997
Stabilization of atmospheric greenhouse gases: physical, biological, and socio-economic implications
Geneva: Intergovernmental Panel on Climate Change Secretariat
[IPCC Technical Paper No. 3]

IPCC (Inter-governmental Panel on Climate Change) Secretariat. 1998
The regional impacts of climate change: an assessment of vulnerability
Cambridge: Cambridge University Press. 517 pp.

IPCC (Inter-governmental Panel on Climate Change) Secretariat. 2001
Climate change 2001
Cambridge: Cambridge University Press.

IUCN (International Union for the Conservation of Nature and Natural Resources). 2000
Red List of Threatened Species
Gland, Switzerland: The World Conservation Union.

Kumar K and Parikh J. 1998.
Climate change impacts on Indian agriculture: the Ricardian approach
In *Measuring the Impact of Climate Change on Indian Agriculture,* edited by A Dinar, R Mendelsohn, Everson,

J Parikh, A Sanghi, K Kumar, J Mckinsey, S Lonergar
Washington, DC: The World Bank.
[World Bank Technical Paper No. 402]

Lal M, Singh K K, Rathore L S, Srinivasan G, Saseendran S A. 1996.
Vulnerability of rice and wheat yields in north west India to future changes in climate
Delhi: Center for Atmospheric Sciences, Indian Institute of Technology. 29 pp.
[Technical Report No. A/TR/1-96]

Lonergan S. 1998
Climate warming and India
In *Measuring the Impact of Climate Change on Indian Agriculture,* edited by A Dinar, R Mendelsohn, Everson, J Parikh, A Sanghi, K Kumar, J Mckinsey, S Lonergan.
Washington, DC: The World Bank
[World Bank Technical Paper No. 402]

Malcom J R and Markhan A. 1996
Ecosystem resilience, biodiversity and climate change: setting limits
Parks **6**: 38–49

Malcom J R and Markhan A. 1997
Climate change threats to national parks and protected areas of the United States and Canada
Washington, DC: World Wildlife Fund

Malcom J R and Markhan A. 2000
Global Warming and Terrestrial Biodiversity Decline
Gland, Switzerland: World Wide Fund for Nature

MoEF (Ministry of Environment and Forests). 1998
India: sustaining development
New Delhi: MoEF, Government of India

MoEF (Ministry of Environment and Forests). 2000a
Notification on Ozone Depleting Substances (Regulation and Control) Rules, 2000
New Delhi: MoEF, Government of India

MoEF (Ministry of Environment and Forests). 2000b
Annual Report, 2000
New Delhi· MoEF, Government of India, 212 pp.

Myers N. 1988
Threatened biotas: 'hotspots' in tropical forests
Environmentalist **8**: 187–208

Myers N, Mittermeier R A, Mittermeier C G, da Fonseca G A B, Kents J. 2000
Biodiversity hotspots for conservation priorities
Nature 403: 853–858.

Oberthur S. 1997
Production and Consumption of Ozone-depleting Substances, 1986–1995
Bonn: Deutsche Gesellschaft Fur Technische Zusammenarbeit

ORNL. 1994.
Trends '93: A Compendium of Data on Global Change, pp. 505-584
Tennessee, USA: Carbon Dioxide Information Analysis Centre, Oak Ridge National Laboratory. 984 pp.

Olson D M and Dinerstein E. 1998
The Global 200: a representation approach to conserving the earth's distinctive ecoregions
USA: World Wildlife Fund.

Rao D G and Sinha S K. 1994
Impact of climate change on simulated wheat production in India
In *Implications of climate change for international agriculture: crop modeling study,* edited by C Rosenzweig and A Iglesias
Washington, DC: United States Environment Protection Agency.

Ravindranath N H and Sukumar R. 1998
Climate change and tropical forests in India
Climatic Change **39**(2–3): 563–581

Rodgers W A and Panwar H S. 1988
Planning a Wildlife Protected Area Network in India, vol. 1.
Dehra Dun: Wildlife Institute of India. 341 pp.

Rodgers W A, Panwar H S, and Mathur V B. 2000
Wildlife Protected Area Network in India: a review (executive summary)
Dehra Dun: Wildlife Institute of India. 44 pp.

Sanghi A, Mendelsohn R, and Dinar A. 1998
The climate sensitivity of Indian agriculture.
In *Measuring the Impact of Climate Change on Indian Agriculture,* edited by A Dinar, R Mendelsohn, Everson, J Parika, A Sanghi, K Kumar, J Mckinsey, S Lonergan.
Washington, DC: The World Bank.
[World Bank Technical Paper No. 402]

Seshu D V and F B Cady. 1984
Responses of rice to solar radiation and temperature estimated from international yield trials
Crop Science **24**: 649–654

Sinha S K. 1989
Global warming and food security in developing countries
In *Proceedings of the International Conference on Global Warming and Climate Change: Perspectives from Developing Countries,* edited by R K Pachauri and S Gupta
New Delhi: Tata MacGraw Hill. 294 pp.

Sinha S K and Swaminathan M S. 1991
Deforestation, climate change, and sustainable nutrition security: a case study of India
Climatic Change **19**: 201–209

Soule M E. 1991
Conservation tactics for a constant crisis
In *Perspectives on Biodiversity: case studies of genetic resource conservation and development, edited by* C S Potter, J I Cohen, D Janczewski, 3–17 pp.
Washington, DC: American Association for the Advancement of Science.

TERI (Tata Energy Research Institute). 1996
The economic impact of a one-metre sea level rise on the Indian coastline: method and case studies
New Delhi: TERI
Submitted to Ford Foundation [Report No 93/GW/52]

TERI (Tata Energy Research Institute). 1998
Climate Change: post-Kyoto perspectives from the south
New Delhi: TERI. 163 pp

TERI (Tata Energy Research Institute). 1999
Climate of Concern: bridging the gap
New Delhi: TERI. 163 pp.

UNEP (United Nations Environment Programme). 1989
Criteria for Assessing Vulnerability to sea level rise: a global inventory to high risk areas
Delft, The Netherlands: Delft Hydraulics, 51 pp.

UNEP (United Nations Environment Programme). 1992
The Impacts of Ozone-Layer Depletion
Nairobi: UNEP. 35 pp.

UNEP (United Nations Environment Programme). 1999
UNEP Press Backgrounder. Version 1.2
www.unep.ch/ozone/PressBack
(Accessed on 13 July 1999)

UNEP (United Nations Environment Programme). 2000
UNEP Press Backgrounder
www.unep.ch/ozone/PressBack.
(Accessed on 3 May 2000)

UNEP (United Nations Environment Programme). 2001
South Asian consultation on atmospheric issues
Organized by UNEP, CUTS, and SAWTEE, May 2001, New Delhi, India

Wigley T M L. 1999
The Science of Climate Change: Global and US Perspectives
Arlington, Virginia: Pew Center on Global Climate Change. 48 pp.

WMO (World Meteorological Organization). 1999
WMO Antarctic Ozone Bulletin # 12/99
(Issued on 17 December 1999)
Geneva: WMO

Wood A, Stedman-Edwards P, and Mang J (eds). 2000
The Root Causes of Biodiversity Loss
UK: World Wide Fund for Nature. 399 pp.

WRI (World Resources Institute). 1998
World Resources 1998/99
Washington, DC: WRI

WRI (World Resources Institute). 2000
A Guide to World Resources 2000–2001. People and Ecosystems: the fraying web of life
Washington, DC: WRI

Table 4.48 Status category summary by major taxonomic group (animals)

Class	Extinct	Extinct in the wild	Sub-total	Critically endangered	Endangered	Vulnerable	Sub-total	Lower risk conservation dependent	Lower risk near threatened	Data deficient	Total
Vertebrates											
Mammalia	83	4	87	180	340	610	1130	74	602	240	2133
Aves	128	3	131	182	321	680	1183	3	727	79	2123
Reptilia	21	1	22	56	79	161	296	3	74	59	454
Amphibia	5	0	5	25	38	83	146	2	25	53	231
Cephalaspidomorphi	1	0	1	0	1	2	3	0	5	3	12
Elasmobranchii	0	0	0	3	17	19	39	4	35	17	95
Actinopterygii	80	11	91	152	126	431	709	12	96	251	1159
Sarcopterygii	0	0	0	1	0	0	1	0	0	0	1
Sub-total	318	19	337	599	922	1986	3507	98	1564	702	6208
Invertebrates											
Echinoidea	0	0	0	0	0	0	0	0	1	0	1
Arachnida	0	0	0	0	1	9	10	0	1	7	18
Chilopoda	0	0	0	0	0	1	1	0	0	0	1
Crustacea	8	1	9	56	72	280	408	9	1	32	459
Insecta	72	1	73	45	118	392	555	3	76	40	747
Merostomata	0	0	0	0	0	0	0	0	1	3	4
Onychophora	3	0	3	1	3	2	6	0	1	1	11
Hirudinoidea	0	0	0	0	0	0	0	0	1	0	1
Oligochaeta	0	0	0	1	0	4	5	0	1	0	6
Polychaeta	0	0	0	1	0	0	1	0	0	1	2
Bivalvia	31	0	31	52	28	12	92	5	60	7	195
Gastropoda	260	12	272	170	209	467	846	14	177	513	1822
Enopla	0	0	0	0	0	2	2	0	1	3	6
Turbellaria	1	0	1	0	0	0	0	0	0	0	1
Anthozoa	0	0	0	0	0	2	2	0	0	1	3
Sub-total	375	14	389	326	431	1171	1928	31	321	608	3277
Total Animalia	693	33	726	925	1353	3157	5435	129	1885	1310	9485

Source
IUCN. 2000. ***Red List of Threatened Species***. Gland, Switzerland International Union for the Conservation of Nature and Natural Resources (World Conservation Union).

Table 4.49 Status category summary by major taxonomic group (plants)

Class	*Extinct*	*Extinct in the wild*	*Sub-total*	*Critically endangered*	*Endangered*	*Vulnerable*	*Sub-total*	*Lower risk conservation dependent*	*Lower risk near threatened*	*Data deficient*	*Total*
Mosses											
Bryopsida	2	0	2	10	15	11	36	0	0	0	38
Anthocerotopsida	0	0	0	0	1	1	2	0	0	0	2
Marchantiopsida	1	0	1	12	16	14	42	0	0	0	43
Subtotal	3	0	3	22	32	26	80	0	0	0	83
Gymnosperms											
Coniferopsida	0	1	1	17	40	83	140	24	52	33	250
Ginkgoopsida	0	0	0	0	1	0	1	0	0	0	1
Subtotal	0	1	1	17	41	83	141	24	52	33	251
Dicotyledons											
Magnoliopsida	69	14	83	896	1110	3093	5099	203	610	298	6293
Monocotyledons											
Liliopsida	1	2	3	79	83	129	291	17	45	39	395
Total plants	70	17	87	992	1234	3305	5531	244	707	370	6939

Source

IUCN. 2000. ***Red List of Threatened Species***. Gland, Switzerland: International Union for the Conservation of Nature and Natural Resources (World Conservation Union).

Table 4.50 Countries ranked according to percentage of their territory with unusually high required migration rates (≥ 1000 m/year)

Country	*Country percentage*[a]
Finland	59.9
Uruguay	43.9
Kuwait	41.1
Russia	38.3
Estonia	34.9
Iceland	34.6
Sweden	34.4
Canada	33.1
Cuba	32.1
Latvia	31.0
Thailand	30.0
Burkina Faso	30.0
United Kingdom	29.8
Portugal	29.5
Benin	28.8
Cambodia	27.9
Taiwan	27.5
Bangladesh	27.2
Ireland	26.3
Dominican Republic	26.2

[a] Averaged across 14 combinations of global climate and vegetation models

Source

Malcom J R and Markhan A. 2000. ***Global Warming and Terrestriel Biodiversity Decline.*** Gland, Switzerland: World Wide Fund for Nature.

Table 4.51 Biodiversity hotspots

Hotspot	Original extent of primary vegetation (km^2)	Remaining primary vegetation (km^2)	% of original extent	Area protected (km^2)	% of hotspots	Plant species	Endemic plants	% of global plants (300 000)	Vertebrate species	Endemic vertebrates	% of global vertebrates (27/2/98)
Tropical Andes	1 258 000	314 500	25.0	79 687	25.3	45 000	20 000	6.7	3389	1567	5.7
Mesoamerica	1 155 000	231 000	20.0	138 437	59.9	24 000	5 000	1.7	2859	1159	4.2
Caribbean	263 500	29 840	11.3	29 840	100.0	12 000	7 000	2.3	1518	779	2.9
Brazil's Atlantic Forest	1 227 600	91 930	7.5	33 084	35.9	20 000	8 000	2.7	1361	567	2.1
Choc Darien/Western Ecuador	260 600	63 000	24.2	16 471	26.1	9 000	2 250	0.8	1625	418	1.5
Brazil's Cerrado	1 783 200	356 630	20.0	22 000	6.2	10 000	4 400	1.5	1268	117	0.4
Central Chile	300 000	90 000	30.0	9 167	10.2	3 429	1 605	0.5	335	61	0.2
California Floristic Province	324 000	80 000	24.7	31 443	39.3	4 426	2 125	0.7	584	71	0.3
Madagascar[a]	594 150	59 038	9.9	11 548	19.6	12 000	9 704	3.2	987	771	2.8
Eastern Arc and Coastal Forests of Tanzania/Kenya	30 000	2 000	6.7	2 000	100.0	4 000	1 500	0.5	1019	121	0.4
Western African Forests	1 265 000	126 500	10.0	20 324	16.1	9 000	2 250	0.8	1320	270	1.0
Cape Floristic Province	74 000	18 000	24.3	14 060	78.1	8 200	5 682	1.9	562	53	0.2
Succulent Karoo	112 000	30 000	26.8	2 352	7.8	4 849	1 940	0.6	472	45	0.2
Mediterranean Basin	2 362 000	110 000	4.7	42 123	38.3	25 000	13 000	4.3	770	235	0.9
Caucasus	500 000	50 000	10.0	14 050	28.1	6 300	1 600	0.5	632	59	0.2
Sundaland	1 600 000	125 000	7.8	90 000	72.0	25 000	15 000	5.0	1800	701	2.6
Wallacea	347 000	52 020	15.0	20 415	39.2	10 000	1 500	0.5	1142	529	1.9
Philippines	300 800	9 023	3.0	3 910	43.3	7 620	5 832	1.9	1093	518	1.9
Indo-Burma	2 060 000	100 000	4.9	100 000	100.0	13 500	7 000	2.3	2185	528	1.9
South Central China	800 000	64 000	8.0	16 562	25.9	12 000	3 500	1.2	1141	178	0.7
Western Ghats/ Sri Lanka	182 500	12 450	6.8	12 450	100.0	4 780	2 180	0.7	1073	355	1.3
SW Australia	309 850	33 336	10.8	33 336	100.0	5 469	4 331	1.4	456	100	0.4
New Caledonia	18 600	5 200	28.0	526.7	10.1	3 332	2 551	0.9	190	84	0.3
New Zealand	270 500	59 400	22.0	52 068	87.7	2 300	1 865	0.6	217	136	0.5
Polynesia/Micronesia	46 000	10 024	21.8	4 913	49.0	6 557	3 334	1.1	342	223	0.8
Total	17 444 300	2 122 891	12.2	800 767	37.7	–[b]	133 149	44.0	–[b]	9645	35.0

[a] Madagascar includes the nearby islands of Mauritius Reunion, Seychelles and Comores

[b] These totals cannot be summed owing to overlapping between hotspots

Source

Myers N, Mittermeier R A, Mittermeier C G, da Fonseca G A B, Kents J. 2000. **Biodiversity hotpots for conservation priorities** *Nature* 403 853-858.

Table 4.52 The eight 'hottest' biodiversity hotspots in terms of five factors

Hotspot	*Endemic plants*	*Endemic vertebrates*	*Endemic plants area ratio (species per 100 km^2)*	*Endemic vertebrates area ratio (species per 100 km^2)*	*Remaining primary vegetation as % of original extent*	*Times appearing in top 10 for each of the five factors*
Madagascar	9 704 (4)	771 (4)	16.4 (8)	1.3 (7)	9.9 (9)	5
Philippines	5 832 (8)	518 (9)	64.7 (2)	5.7 (2)	3.0 (1)	5
Sundaland	15 000 (2)	701 (5)	12.0 (10)	0.6 (10)	7.8 (7)	5
Brazil's Atlantic forest	8 000 (5)	654 (6)	8.7	0.6 (10)	7.5 (6)	4
Caribbean	7 000 (6)	779 (3)	23.5 (6)	2.6 (4)	11.3	4
Indo-Burma	7 000 (6)	528 (8)	7.0 (7)	0.5	4.9 (3)	3
Western Ghats/Sri Lanka	2 180	355	17.5 (1)	2.9 (3)	6.8 (5)	3
Eastern Arc and Coastal Forests of - Tanzania/Kenya	1 500	121	75.0	6.1 (1)	6.7 (4)	3

[a] Values in parentheses represent the position in top 10 biodiversity hotspots for each factor

Source

Myers N, Mittermeier R A, Mittermeier C G, da Fonseca G A B, Kents J. 2000. **Biodiversity hotspots for conservation priorities.** *Nature* 403:853-858.

Table 4.53 Comparative statement of recorded number of plant species in India and the world

Taxa	*Number of species*		*Percentage of India to the world*
	India	*World*	
Bacteria	850	4 000	21.25
Viruses	Unknown	4 000	–
Algae	6 500	40 000	16.25
Fungi	14 500	72 000	20.14
Lichens	2 000	17 000	11.8
Bryophyta	2 850	16 000	17.8
Pteridophyta	1 100	13 000	8.46
Gymnosperms	64	750	8.53
Angiosperms	17 500	250 000	7.00
Total	44 514	412 754	10.78

Source

MoEF. 1999. **National Policy and Macrolevel Action Plan on Biodiversity.** New Delhi: Ministry of Environment and Forests, Government of India

Table 4.54 Comparative statement of recorded number of animal species in India and the world

Taxa	*Number of species* India	*Number of species* World	*Percentage of India to the world*
Protista	2 577	31 259	8.24
Mollusca	5 070	66 535	7.62
Arthropoda	68 389	987 949	6.90
Other invertebrates	8 329	87 121	9.56
Protochordata	119	2 106	5.65
Pisces	2 546	21 723	11.72
Amphibia	209	5 150	4.06
Reptilia	456	5 817	7.84
Aves	1 232	9 026	13.66
Mammalia	390	4 629	8.42
Total	89 317	1 221 315	7.31

Source
MoEF. 1999. **National Policy and Macrolevel Action Plan on Biodiversity.** New Delhi: Ministry of Environment and Forests, Government of India

Table 4.55 Endemic species of plants

Group	*Number of species*
Pteridophyta	200
Angiosperms	4950

Source
MoEF. 1999. **National Policy and Macrolevel Action Plan on Biodiversity.** New Delhi: Ministry of Environment and Forests, Government of India

Table 4.56 Endemic species of animals

Group	*Number of species*
Mollusca	
Land	878
Freshwater	89
Insecta	16 214
Amphibia	110
Reptilia	214
Aves	69
Mammalia	38

Source
MoEF. 1999. **National Policy and Macrolevel Action Plan on Biodiversity.** New Delhi: Ministry of Environment and Forests, Government of India

Table 4.57 Wild relatives of some crops and medicinal plants

Type of crop	*Number of wild relatives*
Millets	51
Fruits	104
Spices and condiments	27
Vegetables and pulses	55
Fibre crops	24
Oil seeds, tea, coffee, tobacco, and sugar cane	12
Medicinal plants	3000

Source
MoEF. 1999. **National Policy and Macrolevel Action Plan on Biodiversity.** New Delhi: Ministry of Environment and Forests, Government of India

Table 4.58 Threatened species of India

Taxonomic group	*Number of threatened species*
Mammals	86
Birds	70
Reptiles	25
Amphibians	3
Fish	3
Molluscs	2
Other Invertebrates	21
Plants	244
Total	459

Source
IUCN. 2000. ***Red List of Threatened Species.*** Gland, Switzerland: International Union for the Conservation of Nature and Natural Resources (World Conservation Union).

Table 4.59 Threatened plants of India by status category

Category	*Number of threatened plants*
Extinct	7
Extinct in the wild	2
Critically endangered	44
Endangered	113
Vulnerable	87
Lower risk conservation dependent	1
Lower risk near threatened	72
Data deficient	14

Source
IUCN. 2000. ***Red List of Threatened Species.*** Gland, Switzerland: International Union for the Conservation of Nature and Natural Resources (World Conservation Union)

Table 4.60 Threatened animals of India by status category

Category	*Number of threatened animals*
Extinct	0
Extinct in the wild	0
Critically endangered	18
Endangered	54
Vulnerable	143
Lower risk conservation dependent	10
Lower risk near threatened	99
Data deficient	31

Source
IUCN. 2000. ***Red List of Threatened Species***. Gland, Switzerland: International Union for the Conservation of Nature and Natural Resources (World Conservation Union)

Table 4.61 Biosphere reserves of India

Site	*Date of notification*	*Area* (km^2)	*Location (State)*
Nilgiri	1 August 1986	5 520	Part of Wynad, Nagarhole, Bandipur and Mudumalai, Nilambur, Silent Valley and Siruvani hills (Tamil Nadu, Kerala, and Karnataka)
Nanda Devi	18 January 1988	5 860.69	Part of Chamoli, Pithoragarh, Almora districts (Uttaranchal)
Nokrek	1 September 1988	820	Part of Garo Hills (Meghalaya)
Manas	14 March 1989	2 837	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamprup, and Darang districts (Assam)
Sunderbans	29 March 1989	9 630	Part of delta of Ganga and Brahamaputra river system (West Bengal)
Gulf of Mannar	18 February 1989	10 500	Indian part of Gulf of Mannar between India and Sri Lanka (Tamil Nadu)
Great Nicobar	6 January 1989	885	Southern most islands of Andaman and Nicobar (A&N islands)
Similipal	21 June 1994	4 374	Part of Mayurbhanj district (Orissa)
Dibru-Saikhowa	28 July 1997	765	Part of Dibrugarh and Tinsukia district (Assam)
Dehang Debang	3 September 1998	5 112	Part of Siang and Debang valley (Arunachal Pradesh)
Pachmarhi	3 March 1999	4 926.28	Part of Betul, Hoshangabad, and Chindwara districts (Madhya Pradesh)
Kanchanjunga	7 February 2000	2 619.92	Part of Kanchanjunga hills (Sikkim)

Source
MoEF. 2000. ***Annual Report 2000–2001***.New Delhi: Ministry of Environment and Forests, Government of India

Table 4.62 India's World Heritage sites

Site	*Location*
Kaziranga National Park	Assam
Keoladeo Ghana National Park	Rajasthan
Manas Wildlife Sanctuary	Assam
Nanda Devi National Park	Uttar Pradesh
Sundarban National Park	West Bengal

Source
MoEF. 1999. **National Policy and Macrolevel Action Plan on Biodiversity.**
New Delhi: Ministry of Environment and Forests, Government of India

Table 4.63 Total existing and proposed protected areas (national parks and sanctuaries) in India by biogeographic zone

Biogeographic zone	*Zone area* (km²)	*% of India*	*No of NPs*	*Area* (km²)	*No. of proposed NPs*	*Area* (km²)	*Total % of zone (NPs)*	*No. of WLS*	*Area* (km²)	*No. of proposed WLS*	*Area* (km²)	*Total % of zone (WLS)*	*Total % of zone (WLS+NP)*
Trans-Himalaya	184 823	5.62	3	6 559.00	6	1 478 00	4.35	4	10 443.50	13	4 885.0	3.44	12.64
Himalaya	210 662	6 41	12	7 518 28	10	2 337.00	4 68	55	13 372.24	19	2 795.5	2.44	12.35
Desert	215 757	6.56	1	3 162.00	4	3 601 00	3.13	5	12 914.08	11	4 032.9	0.20	7.25
Semi-Arid	545 850	16 60	8	1 319.17	7	968 00	0.42	83	13 983.43	11	94.5	0.19	3.00
Western Ghats	132 606	4 03	12	3 334 22	7	2 209.66	4.18	44	10 090.79	25	3 983.1	4.67	14.79
Deccan Peninsula	1 380 380	41.99	21	8 570.93	14	4 024 57	0.91	116	42 580.81	61	3 221.2	0.52	4.23
Gangetic Plain	354 782	10 79	6	2 363 44	2	179.61	0.72	30	5 285.48	17	421.1	0.17	2.33
Coasts	82 813	2.52	5	1 731.18	2	56.04	2.16	21	3 888.40	17	736.2	0.96	7.74
North East	171 341	5.21	9	1 933.21	8	1 565 60	2.04	28	2 420.91	36	4 218.8	3.38	5.92
Islands	8 249	0 25	8	1 157 14	14	839.00	24.20	94	372.13	8	610.6	17.57	36.11
Total	3 287 263	100 00	86	37 648.57	74	17 258.48		480	115 351 77		169 333.1		

NP - national parks, WLS - wildlife sactuaries

Table 4.64 Name of the Project Tiger reserves in tiger range states with year of creation and area

Year of creation	*Name of the tiger reserve*	*State*	*Total area* (km^2)
1973/74	Bandipur	Karnataka	866
1999/2000	Nagarhole (extension)	Karnataka	643
1973/74	Corbett	Uttaranchal	1316
1973/74	Kanha	Madhya Pradesh	1945
1973/74	Manas	Assam	2840
1973/74	Melghat	Maharashtra	1677
1973/74	Palamau	Bihar	1026
1973/74	Ranthambhore	Rajasthan	1334
1973/74	Simlipal	Orissa	2750
1973/74	Sundarbans	West Bengal	2585
1978/79	Periyar	Kerala	777
1978/79	Sariska	Rajasthan	866
1982/83	Buxa	West Bengal	759
1982/83	Indravati	Madhya Pradesh	2799
1982/83	Nagarjunsagar	Andhra Pradesh	3568
1982/83	Namdapha	Arunachal Pradesh	1985
1987/88	Dudhwa	Uttar Pradesh	811
1999/2000	Katerniaghat (extension)	Uttar Pradesh	551
1988/89	Kalakad-Mundanthurai	Tamil Nadu	800
1989/90	Valmiki	Bihar	840
1992/93	Pench	Madhya Pradesh	758
1993/94	Tadoba-Andheri	Maharashtra	620
1993/94	Bandhavgarh	Madhya Pradesh	1162
1994/95	Panna	Madhya Pradesh	542
1994/95	Dampha	Mizoram	500
1998/99	Bhadra	Karnataka	492
1998/99	Pench	Maharashtra	257
1999/2000	Pakhui-Nameri	Arunachal Pradesh-Assam	1206
1999/2000	Bori, Satpura, Panchmari	Madhya Pradesh	1486

Source

MoEF. 2000. ***Annual Report 2000/2001***. New Delhi: Ministry of Environment and Forests, Government of India

Table 4.65 Atmospheric concentrations of greenhouse and ozone-depleting gases: 1965 to 1996

Year	*Carbon tetrachloride* (PPT)	*Methyl chloroform* (PPT)	*CFC-11* (PPT)	*CFC-12* (PPT)	*CFC-113* (PPT)	*Total gaseous chlorine* (PPT)	*Nitrous oxide* (PPB)	*Methane* (PPB)
Pre-industrial	–	–	–	–	–	–	285	700[a]
1965	–	–	–	–	–	–	–	–
1966	–	–	–	–	–	–	–	–
1967	–	–	–	–	–	–	–	–
1968	–	–	–	–	–	–	–	–
1969	–	–	–	–	–	–	–	–
1970	–	–	–	–	–	–	–	–
1971	–	–	–	–	–	–	–	–
1972	–	–	–	–	–	–	–	–
1973	–	–	–	–	–	–	–	–
1974	–	–	–	–	–	–	–	–
1975	–	–	–	–	–	–	–	–
1976	–	–	–	–	–	–	–	–
1977	–	–	–	–	–	–	–	–
1978	88	58	139	257	–	1457	298	–
1979	88	63	147	272	–	1529	299	–
1980	90	71	158	289	–	1622	299	–
1981	91	76	166	305	–	1698	299	–
1982	93	82	175	325	26	1871	301	–
1983	94	86	182	341	28	1945	302	–
1984	95	89	190	355	31	2024	303	–
1985	97	93	200	376	36	2127	304	–
1986	98	97	209	394	40	2222	305	1600
1987	100	100	219	411	48	2321	306	1611
1988	101	104	231	433	53	2432	306	1619
1989	101	108	240	452	59	2531	306	1641
1990	102	111	249	469	66	2626	307	1645
1991	102	114	254	483	71	2691	307	1657
1992	101	118	260	496	77	2762	308	1673
1993	101	113	260	502	79	2768	308	1671
1994	101	108	261	509	81	2774	309	1666
1995	99	97	261	519	82	2752	309	1681
1996	99	89	261	522	82	2731	310	1670

PPM - parts per million; PPB - parts per billion; PPT - parts per trillion; CFC - chloroflourocarbon

[a] approximately all estimates are by volume

Source

WRI. 1998. ***World Resources 1998/99***. Washington, DC: World Resources Institute.

Table 4.66 Timetable of reductions from baseline levels

Chemical	*1987 Montreal Protocol*	*1990 London revisions*	*1992 Copenhagen revisions*	*1995 Vienna revisions (developing countries)*	*1997 Montreal revisions (developing countries)*
CFCs (chloroflourocarbons) 11, 12 113, 114 115	Baseline 1986 freeze by 1989 20% by 1993 50% by 1998	Baseline 1986 freeze by 1989 50% by 1995 85% by 1997 100% by 2000	Baseline 1986 freeze by 1989 75% by 1994 100% by 1996	Baseline 1995/97 freeze by 1999 50% by 2005 85% by 2007 100% by 2010	Baseline 1995/97 freeze by 1999 50% by 2005 85% by 2007 100% by 2010
Halons 1211 1301 2402	Baseline 1986 freeze by 1992	Baseline 1986 freeze by 1992 50% by 1995 100% by 2000	Baseline 1986 freeze by 1992 100% by 1994	Baseline 1995/97 freeze by 2002 50% by 2005 100% by 2010	Baseline 1995/97 freeze by 1999 50% by 2005 85% by 2007 100% by 2010
Other CFCs	–	Baseline 1989 20% by 1993 85% by 1997 100% by 2000	Baseline 1989 20% by 1993 75% by 1994 100% by 1996	Baseline 1998/2000 20% by 2003 85% by 2007 100% by 2010	Baseline 1995/97 freeze by 1999 50% by 2005 85% by 2007
Carbontetrachloride	–	Baseline 1989 85% by 1995 100% by 2000	Baseline 1989 85% by 1995 100% by 1996	Baseline 1998/2000 85% by 2005 100% by 2010	Baseline 1995/97 freeze by 1999 50% by 2005 85% by 2007 100% by 2010
Methyl chloroform	–	Baseline 1989 freeze by 1993 30% by 1995 70% by 2000 100% by 2005	Baseline 1989 freeze by 1993 50% by 1994 100% by 1996	Baseline 1998/2000 freeze by 2003 30% by 2005 70% by 2010 100% by 2015	–
Hydrochloroflourocarbon	–	Mandatory reporting non-binding resolution on phase-out	Baseline 1989 freeze by 1996 35% by 2004 65% by 2010 90% by 2015 99.5% by 2020 100% by 2030	Baseline 2015 freeze by 2016 100% by 2040	–
Hydrobromofluorocarbon	–	–	100% by 1996	100% by 1996	–
Methyl bromide	–	–	Baseline 1991 freeze by 1995	Baseline 1995/98 freeze by 2002 Developed countries baseline 1991 freeze by 1995 25% by 2001 50% by 2005 100% by 2010	baseline 1995/98 freeze by 2002 20% by 2005 100% by 2015 Developed countries baseline 1991 freeze by 1995 25% by 1999 50% by 2001 70% by 2003 100% 2005

Sources

1 Benedick R E. 1998. **Ozone Diplomacy: New Directions in Safeguarding the Planet.** Cambridge: Harvard University Press.

2 UNEP. 2000. **UNEP press backgrounder** http://www.unep ch/ozone/Press Back. (Accessed on 3 May 2000).

Table 4.67 Estimated production of ozone depleting substances (**tonnes**) for India: 1996 to 2010

	1996	*2000*	*2005*	*2007*	*2010*
Chlorofluorocarbon-11	3 420	2 430	1250	200	0
Chlorofluorocarbon-12	4 860	4 000	790	170	0
Chlorofluorocarbon-113	740	630	250	120	0
Halon-1211	600	600	300	180	0
Halon-1301	340	340	170	100	0
Carbon tetrachloride	11 660	13 800	2590	960	0
Methylchloroform	1120	1 050	530	40	0
Total	19 190	16 930	6110	910	0

Note

The table refers to production for indigenous consumption only and does not include exports.

Source

GoI. 1993. **India Country Programme. Phase-out of ozone depleting substances under the Montreal Protocol.** New Delhi: Government of India.

Table 4.68 Global average temperature and atmospheric concentrations of carbon dioxide: 1950 to 1998

Year	*Temperature* (°C)	*Carbon dioxide* (parts per million)	*Emissions from fossil fuel burning* (million tonnes of carbon)
1950	13.84	[?]	1609
1955	13.91	[?]	2009
1960	13.96	316.8	2520
1965	13.88	319.9	3068
1966	13.96	321.2	3222
1967	14.00	322.0	3334
1968	13.94	322.9	3501
1969	14.03	324.5	3715
1970	14.02	325.5	3986
1971	13.93	326.2	4143
1972	14.01	327.3	4306
1973	14.11	329.5	4538
1974	13.92	330.1	4545
1975	13.94	331.0	4518
1976	13.81	332.0	4777
1977	14.11	333.7	4910
1978	14.04	335.3	4950
1979	14.08	336.7	5229
1980	14.18	338.5	5156
1981	14.30	339.8	4984
1982	14.09	341.0	4947
1983	14.28	342.6	4933
1984	14.13	344.2	5098
1985	14.10	345.7	5271
1986	14.16	347.0	5453
1987	14.28	348.8	5575
1988	14.32	351.3	5799
1989	14.24	352 8	5892
1990	14.40	354.0	5946
1991	14.36	355.5	6021
1992	14.11	356.3	5928
1993	14.12	357.0	5896
1994	14.21	358.9	6034
1995	14.38	360.9	6212
1996	14.32	362.7	6316
1997	14.40	363.8	6394
1998	14.57	366.7	6381

Source

Brown L R, Renner M, and Halweil S. 1999. ***Vital Signs 1999/2000*****: The *****Environmental Trends that are Shaping our Future.*** London: Earthscan Publications Ltd. 197 pp.

Table 4.69 GHGs (greenhouse gases) and their main characteristics

	Carbon dioxide	*Methane*	*Nitrous oxide*	*CFC-12*	*HCFC-22 (a CFC substitute)*	*CF-4 (a perfluorocarbon)*
GHG concentrations						
Pre-industrial	280 PPMV	700 PPBV	275 PPBV	–	–	–
1992	356 PPMV	1714 PPBV	311 PPBV	268 PPTV	100 PPTV	32 PPTV
1994	358 PPMV	1720 PPBV	312 PPBV[b]	268 PPTV[b]	110 PPTV	72 PPTV[b]
Rate of concentration change[a]	1.5 PPMV/year	10 PPBV/year	0.8 PPBV/year	0 PPTV/year	5 PPTV/year	1. 2 PPTV/year
0.4%/year	0.6%/year	0.25/year	0%/year	5%/year	2%/year	
Atmospheric lifetime (years)	50-200[c]	12[d]	120	50	12	50000
Global warming potential (years)						
20	1	56[a]	280	7900	4300	4400
100	1	21	310	8500	1700	6500
500	1	6.5	170	4200	520	10000
Radiative forcing						
W/m^2 PPBV	1.8×10^{-5}	3.7×10^{-4}	3.7×10^{-3}	0.22	0.19	0.10
W/m^2	1.56	0.47	0.14	0.06	0.02	0.007

PPMV - parts per million volume; PPBV - parts per billion volume; PPTV - parts per trillion volume; CFC - chlorofluorocarbon; HCFC - hydrochlorofluorocarbon

[a] the growth rates of carbon dioxide, methane, and nitrous oxide are averaged

[b] estimated from 1992/93

[c] no single lifetime for carbon dioxide can be defined because of the different rates of uptake by different processes

[d] this has been defined as an adjustment time which takes into account the indirect effect of methane on its own lifetime

Sources

1 IPCC (Intergovernmental Panel on Climate Change). 1995. **Climate Change 1994: Radiative Forcing of Change and an Evaluation of the IPCC IS92 Emission Scenario** New York: Cambridge University Press.

2 IPCC (Intergovernmental Panel on Climate Change) 1996 **Climate Change 1995: The Science of Climate Change. Report of the IPCC Working Group I.** New York Cambridge University Press

For more details, please see TEDDY ONLINE+ [Section: GHGs (sources and sinks)]

Table 4.70 SRES (Special report on emission scenarios) projections of anthropogenic emissions for 2100

	1990	*A1*	*A2*	*B1*	*B2*
Fossil carbon dioxide (GtC/year)	6.2	13.2	28.8	6.5	13.7
Net deforestation (GtC/year)	1.1	-0.6	0.2	1.4	-0.2
Sulphur dioxide (TgS/year)	72.0	28.0	61.0	29.0	47.0

Source

Wigley T M L. 1999. ***The Science of Climate Change: Global and US Perspectives***. Arlington, Virginia: Pew Center on Global Climate Change. 48 pp.

Table 4.71 Quantitative 2 × carbon dioxide damages in different world regions (2.5 °C warming)

Type of damage	*Damage indicator*	*European Union*	*USA*	*Former USSR*	*China*	*Non-OECD*	*OECD*	*World*
Agriculture	Welfare loss (%)	0.21	0.16	0.24	2.1	0.28	0.17	0.23
Forestry	Forest area lost (km²)	52	282	908	121	334	901	1235
Fishery	Reduced catch ('000 tonnes)	558	452	814	464	4326	2503	6829
Energy	Rise in electricity demand (TWh)	54.2	92.0	54.6	17 1	142.7	211.2	353.9
Water	Reduced water availability (km²)	15 3	32.7	24.7	32.2	168.5	62.2	230.7
Coastal protection	Annual capital costs (million dollars/year)	133	176	51	24	51.4	493	1007
Dryland loss	Area lost ('000 km²)	1.6	10.7	23.9	0	99.5	40.4	139.9
Wetland loss	Area lost ('000 km²)	9.9	11.1	9.8	11 9	219.1	33.9	253
Ecosystems loss	Number of protected habitats lost Assuming 2% loss	16	8	–	4	53	53	106
Health/mortality	Number of deaths ('000)	8.8	6.6	7.7	29 4	114.8	22.9	137.7
Air pollution	Equivalent increase in emissions ('000 tonnes nitrogen oxide)	566	1.073	1 584	227	2602	1943	4545
	('000 tonnes sulphur)	285	422	1.1	258	1864	873	2737
Migration	Additional immigrants ('000)	229	100	153	583	2279	455	2734
Hurricanes								
Casualties	Number of deaths	–	72	44	779	7687	313	8000
Damages	Million dollars	–	115	1	13	124	506	630

OECD – Organization for Economic Co-operation and Development

Source

IPCC (Intergovernmental Panel on Climate Change). 1996. **Climate Change 1995. The Economic and Social Dimensions of Climate Change. Report of IPCC Working Group III.** New York: Cambridge University Press.

Table 4.72 Aggregate monetary damage for 2 × carbon dioxide (annual damages)

Region	*Damage/GDP (%)*[a]
Developed countries (Organization for Economic Co-operation and Development)	1-2
Developing countries with economies in transition	2-9
World	1.5-2.0

[a] gross domestic product corrected for differences in purchasing power parity

Source

IPCC (Intergovernmental Panel on Climate Change). 1996. **Climate Change 1995: The Science of Climate Change. Report of the IPCC Working Group I.** New York: Cambridge University Press.

Table 4.73 Effect of 1-m sea-level rise on coastal area and population

State / Union Territory	*Coastal area* (million hectares) *Total*	*Inundated*	*Percentage*	*Population* (million hectares) *Total*	*Affected*	*Percentage*
State						
Andhra Pradesh	27.50	0.06	0.19	66.36	0.62	0.93
Goa	0.37	0.02	4.34	1.17	0.09	7.25
Gujarat	19.60	0.18	0.92	41.17	0.44	1.07
Karnataka	19.18	0.03	0.15	44.81	0.25	0.56
Kerala	3.89	0.01	0.30	29.08	0.45	1.56
Maharashtra	30.77	0.04	0.13	78.75	1.38	1.75
Orissa	15.57	0.05	0.31	31.51	0.56	1.76
Tamil Nadu	13.01	0.07	0.52	55.64	1.62	2.91
West Bengal	8.88	0.12	1.38	67.98	1.60	2.35
Union Territory						
Andaman and Nicobar Islands	0.83	0.01	0.72	0	0	0
India	139.59	0.57	0.41	416.74	7.10	1.68

Note

Coastal area and population are based on the 1981 and 1991 censuses.

Source

JNU. 1993. **Impact of greenhouse induced sea-level rise on the islands and coasts of India.** New Delhi: Department of Environment and Forests, Jawaharlal Nehru University.

Table 4.74 Impact of 1-m sea-level rise on coastal districts (**billion 1990 rupees**) (4.5% rate of growth, 5% discount rate)

Coastal areas	*Economic impact*	*Value of anticipation*	*Cost of protection*
Mumbai	2287.0	1061.0	0.76
Goa	81.0	36.5	1.42
Balasore	3.6	1.3	1.25

Source

TERI. 1996. **The economic impact of a 1-m sea-level rise on the Indian coastline: method and case studies.** Report submitted to the Ford Foundation New Delhi: Tata Energy Research Institute.

Table 4.75 Global carbon dioxide emission estimates (**million tonnes of carbon**): 1970 to 1991

Item	*1970*	*1975*	*1980*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*
Total global emissions	4083	4621	5292	5413	5601	5726	5954	6068	6098	6189
Solid	1564	1679	1950	2239	2300	2351	2413	2454	2393	2342
Liquid	1838	2131	2407	2170	2276	2287	2394	2429	2482	2591
Gas	516	623	726	818	835	897	940	976	1004	1024
Cement	78	95	120	131	137	143	152	156	157	162
Gas flaring	87	93	89	55	53	48	55	53	62	70
Per capita emission of carbon (tonnes)	1.1	1.13	1.19	1.12	1.13	1.14	1.16	1.17	1.15	1.15

Source

Marland G, Andres R J, and Boden T A. 1994. **Global, regional, and national carbon dioxide emissions.** In ***Trends '93: A Compendium of Data on Global Change***, pp. 505–584, edited by T A Boden, D P Kaiser, R J Sepanski, F W Stoss. Tennessee, USA: Carbon Dioxide Information Analysis Centre, Oak Ridge National Laboratory. 984 pp. [ORNL/CDIAC-65]

For more details, please see TEDDY ONLINE+ [Section: GHGs (global data)]

Table 4.76 Carbon dioxide emission estimates (**million tonnes of carbon**) for India: 1970 to 1991

Item	*1970*	*1975*	*1980*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*
Total emissions	53.3	69.10	95.50	134.30	143.60	152.10	163.8	178.50	184.20	192.00
Solid	37.7	49.20	69.70	94.80	101.50	108.50	117.4	126.00	130.10	135.50
Liquid	13.1	16.70	22.40	31.40	32.90	33.70	35.3	39.30	39.60	41.40
Gas	0.3	0.50	0.70	2.00	2.80	3.20	3.5	4.20	5.20	5.30
Cement	1.8	2.20	2.40	4.50	5.00	5.00	5.5	6.30	6.70	6.80
Gas flaring	0.4	0.50	0.30	1.60	1.40	1.70	2.0	2.60	2.70	3.00
Per capita emissions (tonnes of carbon)	0.1	0.11	0.14	0.18	0.18	0.19	0.2	0.22	0.22	0.22
Bunkers[a]	0.5	0.50	0.70	0.50	0.60	0.70	0.9	0.80	0.70	0.70

[a] bunkers refer to emissions expressed in million tonnes of carbon resulting from fuels consumed by ships and aircrafts engaged in international transportation. Emissions from bunker fuels are shown with the country where the fuel loading occurred but are not included in the national total.

Source

Marland G, Andres R J, and Boden T A. 1994. **Global, regional, and national carbon dioxide emissions.** In ***Trends '93: A Compendium of Data on Global Change***, pp. 505–584, edited by T A Boden, D P Kaiser, R J Sepanski, F W Stoss. Tennessee, USA: Carbon Dioxide Information Analysis Centre, Oak Ridge National Laboratory. 984 pp. [ORNL/CDIAC-65]

For more details, please see TEDDY ONLINE + [Section: GHGs (sources and sinks)]

Table 4.77 Greenhouse gas emissions from developed countries:1990 to 1998

Country	CO_2 1990 without sinks	CO_2 1998 without sinks	% change	CO_2 1990 sinks	CO_2 1998 sinks	% change	All GHGs 1990 without sinks	All GHGs 1998 without sinks	% change	Kyoto target (% of 1990 levels)
Australia	278 669	337 973	21 30	70 092	35 173	−49.82	423 237	484 699	14.52	+8
Austria	62 130	66 604	7.20	−9 215	−7633	−17.20	75 452	80 315	6.45	−8 (−13)
Belgium	113 997	121 975	7 00	−2 057	−977	−52.50	136 463	145 372	6.53	−8 (−7.5)
Bulgaria[a, b]	103 856	55 150	−46.90	−4 657	−6 233	33.84	157 090	84 317	−46.32	−8
Canada	465 755	529 431	13 70	−39 141	−21 833	−44.22	611 770	692 230	13.15	−6
Czech[a]	165 490	128 268	−22.49	−2 281	−3 757	64.71	189 837	147 777	−22.16	−8
Denmark	52 894	60 125	13 70	−916	−973	6.22	69 567	76 144	9.45	−8 (−21)
Estonia[a]	37 797	19 232	−49.12	−11 317	−3 356	−70 34	40 719	21 756	−46.57	−8
Finland	60 771	63 945	5 20	−23 798	−9 713	−59.18	75 202	76 315	1.48	−8 (0)
France	387 590	412 860	6.50	−59 617	−69 783	17.05	553 778	558 726	0.89	−8 (0)
Germany	1 014 500	886 181	−12.65	−33 719	−33 493	−0.67	1 208 807	1 019 745	−15.64	−8 (−21)
Greece	85 164	100 449	17.90				105 346	124 315	18.01	−8 (−25)
Hungary[b]	83 676	57 601	−31.16	−3 097	−441	42.40	101 633	83 677	−17.66	−6
Iceland	2 147	2 282	6.30				2 576	2 696	4.66	+10
Ireland	31 575	40 019	26.70	−5 020	−6 448	28.45	53 497	63 718	19.11	−8 (−13)
Italy	432 565	459 461	6 20	−25 614	−23 634	−7.73	518 502	541 542	4.44	−8 (−6.5)
Japan	1 124 532	1 230 831[c]	9.50	−83 903	−96 705[d]	15.30	1 213 262	1 330 555[c]	9.70	−6
Latvia[a]	24 771	8 287	−66.54	−10 826	−10 508	−2.93	35 669	11 504	−67.74	−8
Liechtenstein	208			−22			260			−8
Lithuania[a]	39 535	16 694	−57.77	−8 848	7 712	−187 16	51 448	23 851	−53.73	−8
Luxembourg	12 750	9 545[d]	−25.10	−295	−295[d]	0	13 448	10 223[d]	−24.00	−8 (−28)
Monaco	108	138	27.80				111	142	28.40	−8
The Netherlands	161 360	181 370	12.40	−1 500	−1 700	13.33	217 882	236 251	8.43	−8 (−6)
New Zealand	25 398	28 941	13.90	−21 530	−20 896	−2.94	73 068	74 886	2.49	0
Norway	35 146	41 700	18.60	−9 590	−17 588	83 40	52 141	56 148	7.68	+1
Poland[a b]	476 625	337 450	−29.20	−34 746	−29 820	−14.18	564 286	402 477	−28.67	−6
Portugal	43 132	53 891	24.90	−3 994	−4 674	17 03	63 858	74 870	17.24	−8 (−27)
Romania[a b]	194 826	125 597[e]	−35.50	−2 925	−6590[e]	125.30	264 879	164 026[e]	−38.10	−8
Russian Fed.[a]	2 372 300	1 495 920[f]	−36.90	−392 000	−840 000[f]	114.30	3 040 062	1 962 441[f]	−35.40	0
Slovakia[a]	62 237	43 772	−29.67	−2 426	−1 683	−30.63	76 304	52 818	−30.77	−8
Slovenia[a]	13 935			−2 293			19 212			−8
Spain	226 057	273 017	20.80	−29 252	−29 252	0	305 746	369 856	20.97	−8 (−15)

Sweden	55 443	56 953	2.70	−34 368	−27 680	−19.46	69 399	73 842	6.40	−8 (−4)
Switzerland	44 409	44 809	0.90	−4 343	−6 109	40.70	53 005	53 706	1.32	−8
Ukraine[a]	703 792	314 445	−55.32	−52 107	−68 708	31.90	919 220	454 934	−50.50	0
UK	584 220	546 390	−6.50	21 186	14 984	−29.27	741 489	679 850	−8.31	−8 (−12.5)
USA	4 914 351	5 478 051	11.50	−1 159 994	−773 019	−33.36	6 048 786	6 726 997	11.21	−7
Annex I[g]	14 493 711	13 643 500	−5.87	−1 984 133	−2 067 947	4.20	18 147 110	16 982 195	−6.41	−5
Annex II[g]	10 214 871	11 027 149	8.00	−1 456 610	−1 102 270	−24.32	12 686 651	13 553 405	6.83	–
Economies in transition[g]	4 278 840	2 616 351	−38.85	−527 523	−965 677	83.10	5 460 459	3 428 790	−37.20	–

[a] economies in transition,

[b] Some Parties with economies in transition use base years other than 1990. Bulgaria (1988), Hungary (average of 1985-87), Poland (1998), and Romania (1989). These base years are given in this table in lieu of 1990

[c] latest available data is from 1997

[d] latest available data is from 1995

[e] latest available data is from 1994

[f] latest available data is from 1996

[g] totals for 1998 based on the latest available data for each country.

Notes

1 Negative values indicate net removal of CO_2 from the land-use change and forestry sector; negative values in percentage represent a decrease in removals in relation to those in the year 1990 and positive values indicate an increase in removals, except for Australia and the UK, where the values in percentage change indicate lower emissions or greater removals

2 All GHGs expressed as CO_2 equivalents

3 Figures in parentheses indicate internal targets within the European Union.

Source

Framework Convention on Climate Change Secretariat. 2000. **National Communications from Parties included in Annex I to the Convention: Greenhouse Gas Inventory Data from 1990 to 1998.** Bonn: Framework Convention Climate Change Secretariat. [Document FCCC/SBI/2000/11.]

Table 4.78 Average annual budget of carbon dioxide perturbations: 1980 to 1989

Sources and sinks	*Fluxes and reservoir changes of carbon*
Carbon dioxide sources	
1 Emissions from fossil fuel combustion and cement production	5.5 ± 0.5
2 Net emissions from changes in tropical land use	1.6 ± 1.0
3 Total anthropogenic emissions	7.1 ± 1.1
Partitioning among reservoirs	
4 Storage in the atmosphere	3.2 ± 0.2
5 Oceanic uptake	2.0 ± 0.8
6 Uptake by northern hemisphere forest regrowth	0.5 ± 0.5
Other terrestrial sinks = (3) - (4) + (5) + (6)	
(carbon dioxide fertilization, nitrogen fertilization, climatic effects)	1.3 ± 1.5

Note
Fluxes and reservoir changes of carbon are expressed in gross tonnes of carbon per year; error limits correspond to an estimated 90% confidence interval.

Source
IPCC (Intergovernmental Panel on Climate Change). 1996. **Climate Change 1995: The Science of Climate Change. Report of the IPCC Working Group I.** New York: Cambridge University Press.

Table 4.79 Estimated sources and sinks of methane (Tg per year): 1980 to 1990

Sources and sinks	*Individual estimate*	*Total*
Observed atmospheric increase, estimated sinks, and sources derived to balance the budget		
Atmospheric increase[a]	–	37 (35-40)
Sinks of atmospheric methane		
Tropospheric OH	490 (405-575)	–
Stratosphere	40 (32- 48)	–
Soils	30 (15- 45)	–
Total atmospheric sinks	–	560 (460-660)
Implied total sources (sinks + atmospheric increase)	–	597 (495-700)
Inventory of identified sources		
Natural sources	–	160 (110-210)[a]
Anthropogenic		
Fossil-fuel related	100 (70-120)	–
Total biospheric	275 (200-350)	–
Total anthropogenic sources	–	375 (300-450)
Total identified sources	–	535 (410-660)

[a] applies to 1980-90 average

Source
IPCC (Intergovernmental Panel on Climate Change). 1996. **Climate Change 1995: The Science of Climate Change. Report of the IPCC Working Group I.** New York: Cambridge University Press.

For more details, please see **TEDDY ONLINE+ [Section: GHGs (sources and sinks)]**

Table 4.80 India's national greenhouse gases inventory for 1990 (Gg)

Greenhouse gas sources and sinks	CO_2 *emissions*	CO_2 *removals*	*Methane*	*Nitrous oxide*	*Oxides of nitrogen*	*Carbon monoxide*	CO_2 *equivalent* (CO_2 *+ methane + nitrous oxide)*[a]
Energy							
Fuel combustion	508 600						
Energy and transformation industries	–	–	–	–	2684[c]	3 493[c]	508 600
Biomass burning	300 460[b]	–	1 579	11	400	11 472	36 569
Fugitive emissions from fuels							
Solid fuels	–	–	330	–	–	–	6 930
Oil and natural gas	–	–	626	–	–	–	13 146
Total emissions from energy sector (fuel combustion + fugitive)	508 600	–	2 535	11	3084	14 965	565 245
Industrial processes	24 200	–	–	1	–	–	24 510
Agriculture							
Enteric fermentation	–	–	7 563	–	–	–	158 823
Manure management	–	–	905	–	–	–	19 005
Rice cultivation	–	–	4 070[d]	–	–	–	85 470
Agricultural soils	–	–	–	240	–	–	74 400
Prescribed burning of savannas	–	–	–	–	–	–	–
Field burning of agricultural residues	–	–	116	3	109	3 038	3 366
Total emissions from agricultural sources	–	–	12 654	243	109	3 038	341 064
Land-use change and forestry							
Change in forests and other woody biomass stock	–	-6 171	–	–	–	–	–6171
Forests and grassland conversion	52 385	–	–	–	–	–	52 385
Abandonment of managed lands	–	–44 729	–	–	–	–	-44 729
Total emissions from land-use change and forestry sector	52 066	-50 900	–	–	–	–	1 485
Waste							
Solid waste disposal on land	–	–	334	–	–	–	7 014
Domestic and commercial waste water	–	–	49	–	–	–	1 029
Industrial waste water	–	–	2 905	–	–	–	61 005
Other waste	–	–	–	–	–	–	–
Total emissions from waste	–	–	3 288	–	–	–	69 048
Total national emissions and removals	585 185	-50 900	18 477	255	3193	18 003	1 001 352

[a] CO_2 equivalents are based on the GWP (global warming potential) of 21 for methane and 310 for nitrogen oxide. Nitrous oxide and carbon monoxide are not included since GWPs have not been developed for these gases. Bunker fuel emissions are not included in the national total.

[b] CO_2 emissions from biomass burning are not included in the national totals.

[c] Nitrogen oxides and carbon monoxide emissions are computed for the transport sector.

[b] Methane emissions according to IPCC (Intergovernmental Panel on Climate Change) 1996 methodology.

Source

ADB-GEF-UNDP. 1998. **Asia Least-Cost Greenhouse Gas Abatement Strategy - India.** Manila: Asian Development Bank.

Table 4.81 CO_2-fuel combustion emissions, 1997, largest emitters: Annex I and non-Annex I Parties (**million tonnes of CO_2**)

Annex I and non-Annex I Parties	*Total emissions*	*% World*	*Annex I Parties*	*Total emissions*	*% Annex I*	*Non-Annex I Parties*	*Total emissions*	*% Non-Annex I*
USA	5 470	24	USA	5 470	41	China	3121	35
China	3 121	14	Russian Federation	1 456	11	India	881	10
Russian Federation	1 456	6	Japan	1 173	9	Republic of Korea	422	5
Japan	1 173	5	Germany	884	7	Mexico	346	4
Germany	884	4	UK	555	4	South Africa	345	4
India	881	4	Canada	477	4	Brazil	301	3
UK	555	2	Italy	424	3	Iran	285	3
Canada	477	2	Ukraine	376	3	Saudi Arabia	266	3
Italy	424	2	France	363	3	Indonesia	257	3
Republic of Korea	422	2	Poland	350	3	Thailand	175	2
Total	14 863		Total	11 529		Total	6399	
% of world total	65		% of world total	50%		% of world total	28	
			% of Annex I total	86%		% of non-Annex I total	72	

Groups	**Total emissions**	**% of world total**	**tonnes of CO_2 per capita**
World[a]	22 981	–	3.97
Annex I Parties	13 385	58	11.75
Annex II Parties	10 938	48	12.22
European Union	3 209	14	8.58
EIT Parties	2 696	12	8.48
Annex I (non-EU+EIT)	10 425	45	12.42
non-Annex I Parties	8 928	39	1.95

[a] World includes all Parties and non-Parties to the UN FCCC

Note

Data from IEA has been used as the UN FCCC Secretariat database does not contain data for all parties. However, the IEA data are broadly comparable to that reported to the UN FCCC Secretariat by Parties.

Source

IEA. 1999. **CO_2 emissions from fuel combustion 1971-1997**. Paris: International Energy Agency

Table 4.82 CO_2-fuel combustion emissions, 1997, (per capita emissions) largest emitters: Annex I and non-Annex I Parties (tonnes of CO_2 per capita)

Top 20: Annex I and non-Annex I Parties		*Top 20: Annex I Parties*		*Top 20: non-Annex I Parties*	
Qatar	44.08	USA	20.50	Qatar	44.08
Bahrain	35.23	Luxembourg	20.42	Bahrain	35.23
United Arab Emirates	30.11	Australia	16.52	United Arab Emirates	30.11
Kuwait	25.01	Canada	15.76	Kuwait	25.01
Singapore	23.47	Finland	12.47	Singapore	23.47
United States	20.50	Estonia	12.47	Saudi Arabia	13.27
Luxembourg	20.42	Belgium	12.04	Trinidad and Tobago	13.25
Australia	16.52	Denmark	11.81	Israel	9 37
Canada	15.76	The Netherlands	11.81	Republic of Korea	9.18
Saudi Arabia	13.27	Czech Republic	11.74	South Africa	8.50
Trinidad and Tobago	13.25	Germany	10.77	Cyprus	8.32
Finland	12.47	Ireland	10.27	Kazakhstan	8.02
Estonia	12.47	Russian Federation	9.89	Malta	7.78
Belgium	12.04	UK	9.40	Oman	7.64
Denmark	11.81	Japan	9.29	Libyan Arab Jamahiriya	7 37
The Netherlands	11.81	Poland	9.06	Turkmenistan	6.00
Czech Republic	11.74	Iceland	8.85	Venezuela	6.00
Germany	10.77	New Zealand	8.81	Malaysia	5.71
Ireland	10.27	Austria	7.94	Yugoslavia	4.88
Russian Federation	9.89	Norway	7.79	Iran	4.68

Source
IEA. 1999. **CO_2 emissions from fuel combustion 1971–1997.** Paris: International Energy Agency

Table 4.83 Share in 1990 Annex I CO_2 emissions and emissions reductions below 1990 levels (%) proposed in the Kyoto Protocol

Party	*Share in Annex I emissions*	*Emission reductions (2008-12)*
Australia	2.1	+8
Austria	0.4	–8
Belgium	0.8	–8
Bulgaria	0.6	–8
Canada	3.3	–6
Croatia	–	–5
Czech Republic	1.2	–8
Denmark	0.4	–8
Estonia	0.3	–8
European Union	–	–8
Finland	0.4	–8
France	2.7	–8
Germany	7.4	–8
Greece	0.6	–8
Hungary	0.5	–6
Iceland	0	+10
Ireland	0.2	–8
Italy	3.1	–8
Japan	8.5	–6
Latvia	0.2	–8
Liechtenstein	0	–8
Lithuania	–	–8
Luxembourg	0.1	–8
Monaco	0	–8
The Netherlands	1.2	–8
New Zealand	0.2	0
Norway	0.3	+1
Poland	3.0	–6
Portugal	0.3	–8
Romania	1 2	–8
Russian Federation	17 4	0
Slovakia	0 4	–8
Slovenia	–	–8
Spain	1.9	–8
Sweden	0.4	–8
Switzerland	0.3	–8
Ukraine	–	0
UK	4.3	–8
USA	36.1	–7

Sources

1 FCCC Secretariat. 1997. **Conference of the Parties. Third session.** Kyoto, 1-10 December 1997. Agenda item 5. [FCCC/CP/1997/CRP.4] (9 December 1997). Bonn: The FCCC Secretariat.

2 FCCC Secretariat. 1998. **The Kyoto Protocol to the Convention on Climate Change.** Bonn, Germany: The FCCC Secretariat. 34 pp.

Table 4.84 Cost of various CO_2 mitigation options for India

Technology	*Greenhouse gas emissions reduction*	*Investment cost*	*Cost-effectiveness* (dollars/tonne CO_2)
Transport sector			
CNG (compressed natural gas) car	0.017 kg/P-km	10965 dollars/unit	4 500
CNG bus	0.41 kg/P-km	31000 dollars/unit	12
Mass rapid transport system	–	1.4 billion dollars	0
BOV (battery-operated vehicle) (three-wheeler)	–	2444 dollars/unit	0
Two-wheeler (four-stroke)	0.0014 kg/P-km	1156 dollars/unit	30 000
Renewable energy for power			
Small hydro	1.3 kg/kWh	1950 dollars/kW	88
Wind farms	1.3 kg/kWh	1405 dollars/kW	257
Biomass	1.6 kg/kWh	710 dollars/kW	102
Solar thermal	1.3 kg/kWh	3730 dollars/kW	592
Solar PV (photovoltaic)	1.6 kg/kWh	5952 dollars/kWp	541
Agriculture sector			
Agro-based gasifier	1.6 kg/kWh	760 dollars/kW	119
Wood-based gasifier	1.6 kg/kWh	694 dollars/kW	115
Wind-based shallow pumping	1.6 kg/kWh	1157 dollars/kW	173
Wind-based deep wells	1.6 kg/kWh	2149 dollars/kW	176
PV pump	1.6 kg/kWh	8598 dollars/kWp	1 602
Power generation			
Cogeneration	1.50 kg/kWh	900 dollars/kW	10
Combined cycle	0.96 kg/kWh	818 dollars/kW	54
Inter-cooled steam injected gas turbine	0.76 kg/kWh	947 dollars/kW	77
Pressurized fluidized bed combustion	0.18 kg/kWh	1894 dollars/kW	503
Integrated gasification combined cycle	0.23 kg/kWh	1578 dollars/kW	340
Pulverized coal super-critical boilers	0.18 kg/kWh	1202 dollars/kW	342
Coal washing	0.125 kg/kWh	11 dollars/tonne a year	179
Domestic lighting			
Compact fluorescent lamps	6.49 Tg/year	8 dollars/unit	–
36 W fluorescent	0.09 Tg/year	0.9 dollars/unit	–

P-km (passenger-kilometre)

Source

ADB. 1998. **Asia Least-cost Greenhouse Gas Abatement Strategy**. Manila, The Philippines: Asian Development Bank.

Table 4.85 GEF (Global Environment Facility) projects in India

Project name and type	*Project description*	*GEF allocation* (million dollars)
Fuel-cell bus development in India (project development facility B)	The project consists of two phases. Phase 1 involves assessments of the status and prospects for commercialization of hydrogen fuel-cell bus technology, potential hydrogen resource supplies, and refuelling and infrastructure networks in India. Phase I will culminate in the preparation of a proposal to the GEF for hydrogen fuel-cell bus demonstration and commercialization activities. Phase II will contribute significantly towards achieving the long-term objective of reducing the cost of fuel-cell buses to near-competitive levels in India.	0.297
Optimizing development of small hydel resources in hilly areas (full projects)	The project is designed to assist the Government of India in the optimum utilization of small hydel resources in the Himalayan and sub-Himalayan regions. This will be done by setting up 20 commercially viable small hydel demonstration projects, by upgrading the institutional and human resource capabilities from the local to national levels, and by formulating a national strategy and master plan in this sector. By developing a package of appropriate technologies, and management and ownership models. which are people-centred and environmentally sound, the project will demonstrate the potential to reduce deforestation and protect biodiversity in the eco-fragile Himalayan and sub-Himalayan regions, besides reducing GHG (greenhouse gas) emissions.	7.500
Enabling activity for the preparation of India's initial National Communication to the UN FCCC (UN Framework Convention on Climate Change) (enabling activities)	The project will assist India in undertaking the enabling activities required to prepare initial National Communication to the Conference of Parties in accordance with UN FCCC and to build capacity to fulfil its commitments to the UN FCCC on a continuing basis.	2.000
Selected options for stabilizing GHG emissions for sustainable development (full projects)	The project will build capacity to identify, prioritize, and develop projects in line with national developmental objectives through the institutions in four sectors, namely coal, power, renewables, and forestry. At the end of the project, a number of project proposals will be developed in these identified sectors, which would lead to the adoption of technologies to mitigate climate change. A comphrehensive inventory of efficient, cleaner, and renewable energy technologies will be developed along with a detailed report on best national and international practices.	1.500
Development of high-rate biomethanation processes as means of reducing GHG emissions (full projects)	This project develops a national master plan for generation and utilization of bioenergy, creates commercially viable packages for replication, and promotes and disseminates technology for high-rate biomethanation. The project will introduce, demonstrate, and standardize a wide variety of cost-effective technologies which will lead to reduction in urban and rural waste and its impact on land degradation.	5.500
Coal-bed methane capture and commerical utilization (full projects)	The objectives of this project are to control GHG emissions and demonstrate the economic viability of harnessing coal-bed methane, in the Indian coal mining sector. The full project is intended to build national capacity in the field of coal-bed methane recovery and utilization	9.190

Continued

Table 4.85 continued

Project name and type	*Project description*	*GEF allocation* (million dollars)
Carbon emissions reduction through biomass energy for rural India (SUTRA) (project development facility B)	The aim of this project is to establish the commercial viability of various bio-energy options and their potential for widespread adoption at the village level in India so as to actively promote a low carbon dioxide path to development in India. It would lead to widespread adaptation to meet the energy needs of domestic, farm, and commercial sectors in rural India.	0.196
Biomass energy for rural India (full projects)	This project aims at developing and implementing a bio-energy technology package to reduce GHG emissions by up to 177 tonnes of carbon over the next 25 years, and to promote a sustainable and participatory approach to meeting rural energy needs. The project will be implemented mainly in two panchayats of Tumkur district in Karnataka.The project goals will be achieved through (1) demonstrating the technical feasibility and financial viability of bioenergy technologies on a significant scale; (2) building capacity and developing appropriate mechanisms for implementation, management, and monitoring of the project, (3) developing financial, institutional, and market strategies to overcome the identified barriers for large-scale replication of the bio-energy package for decentralized applications; and (4) disseminating the bio-energy technology and information package on a large scale.	4.017

Source
UNDP (United Nations Development Programme). 2000. **UNDP-GEF portfolio by focal area.** www.undp.org/gef/portf/climate.htm. (Accessed on 15 May 2000.)

Table 4.86 Pilot-phase activities of projects implemented jointly and endorsed by the Government of India

Name of the project	*Location*	*Investing party*	*Host party*
Integrated agriculture demand-side management	Andhra Pradesh	World Bank	Andhra Pradesh State Electricity Board
Direct reduced iron	Gujarat	New Energy Development Organization, Japan	Essar, Gujarat, India
Energy recovery from waste, gas, and liquid	Gujarat	–	Indian Petrochemicals Corporation Ltd, Vadodara, Gujarat, India
DESI - Power: biomass gasification	20 sites in India	The Netherlands	DESI Power, Development Alternatives, India
Tamarind orchard agro-forestry for dryland	Karnataka	USA	ADAT, Bagepalli, Karnataka, India

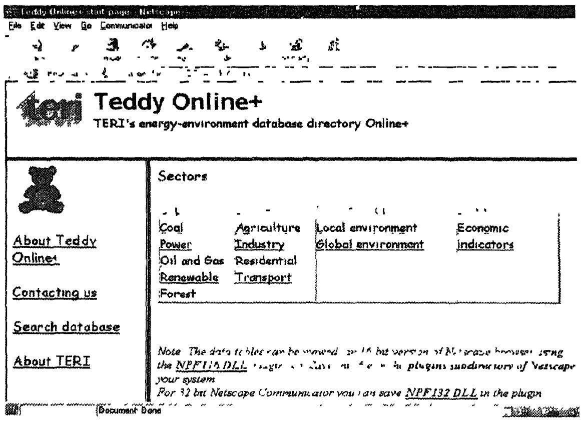
DESI - Decentralized Energy Systems India Private Limited

Source
ADB-GEF-UNDP. 1998. **Asia Least-Cost Greenhouse Gas Abatement Strategy - India.** Manila: Asian Development Bank.

TEDDY ONLINE+

TEDDY ONLINE+ (TERI's Energy–environment Database and Directory Online+) is a computerized database providing ready-to-use information on different sectors of the Indian economy, and some aspects of international economy.

- Comprehensive source of data on energy, environment, and economy.
- Data coverage from 1971 to 2002.
- More than 900 data tables.
- Data constantly refined and updated by experts.
- Source of data for many national and international research projects.



For 32 bit Netscape Communicator you can save NPF132.DLL in the plugin

The new WINWEB interface of TEDDY ONLINE+

The new WINWEB version of TEDDY ONLINE+ is a Windows based stand-alone database with web interface and displays data tables in spreadsheet layout. The interface is extremely user-friendly and requires no computer skills to operate the database; with few clicks of mouse button, user can select a table from any sector and view data. For analysis of data or for any other use, one can save data tables in MS Excel worksheets or in text files; or one can print the data directly on any printer.

Price Rs 7500 / US $750

All orders and enquiries to

Information Dissemination Services
TERI
Darbari Seth Block
Habitat Place, Lodhi Road
New Delhi - 110 003, India

Fax +91 11 468 2144, 468 2145
E-mail outreach@teri.res.in
Telephone +91 11 468 2100, 468 2111
Web site www.teriin.org

Demo copy of TEDDY Online+ is available at www.teriin.org\pubcat\teddyo\activate.htm

Appendix I

Disaggregation of data by sector in **Teddy Online+**
[*The new* WIN-WEB *version of the database is available on floppies.*]

Energy supply

Coal	General Production Closing stock Prices and unit values Transport Plan statistics	Reserves Despatches Offtake Trade International data
Oil and gas	General Refining – capacity and throughput, stocks Transportation Exports and imports Financial structure and resources Plan statistics	Exploration, reserves, and production Sales and consumption Marketing network Prices Sales tax and excise/custom duties International – reserves, production, consumption, refining, trade, gas liquefaction, prices
Power	Capacity and generation – thermal, utility, hydro, nuclear, captive State electricity boards Rural Human resources Plan statistics	Load survey Utilization Transmission Finance – subsidy, costs and revenues, tariff Power development International data
Renewables	Actual and potential Solar Wind Fiscal/promotional incentives International data	Biogas Hydro Tidal Plan statistics
Forests	Land utilization Afforestation and regeneration Imports and exports Non-forest data Macro- and state-level data Externally aided projects International data	Forest cover Forest area lost Forest out-turn and inventory National parks Trade Plan statistics

Energy demand

Agriculture

- Area, yield, and production
- Stocks
- Fertilizers, pesticides, and other inputs
- Rainfall and drought
- Labour force
- Prices
- Aquaculture and fish
- International data
- Procurement
- Land-related statistics
- Irrigation-related statistics
- Mechanization
- Livestock
- Infrastructure
- Outlays and expenditure
- Agriculture and national income

Industrial

- General
- Soda ash
- Fertilizers
- Sugar
- Aluminium
- Cement
- Iron and steel
- Textiles

Residential

- General
- Production of appliances
- Fuel/energy consumption

Transport

- General
- Railways
- Water transport
- Roads and road transport
- Air transport
- Inland water transport

Environment

Local environment

- Air emissions – general, industry, power, refineries, transport, domestic
- General impact on health
- International data
- Water emissions – general, industry
- Solid wastes
- Noise
- Plan statistics

Global environment

- Sources and sinks
- Mitigation technologies
- Selected countries emission profile
- Impacts
- Global data

Economy

Economic indicators

- General
- Macro aggregates
- Trade, investment, and balance of payments
- Miscellaneous
- Linkages with energy
- Demographic statistics
- Subsidies
- Debt
- Prices
- Plan statistics
- International data

Index

A

'buy down' arrangement in US 3
1-m sea-level rise on
    coastal area and population, effects of 428
    coastal districts, impact of 428
2 × carbon dioxide
    damages in different world regions 427
    aggregate monetary damage for 427
2T oil, specifications for 249
accelerated power development programme 114
administered pricing mechanism (*see* APM)
AEC (Atomic Energy Commission) 11
aerogenerator systems, statewise installation of 165
aerogenerators/wind battery chargers 164
agricultural consumers, subsidy for 142
agricultural development in future 200
agricultural development programmes, progress of 206
agricultural perspective 216
agricultural production, vulnerability to climate change 402
agricultural sector
    contribution to GDP and NDP 202
    impact of policy issues on 221
    share of electricity in 199
    share of oil in 199
agriculture 402
agriculture at a glance 197
agriculture inputs
    fertilizers 198
    land 198
    pesticides 199
    seeds 198
    water 198
agriculture sector
    consumption of electricity by 200
    public sector plan outlays on the 215
agriculture
    energy used in 199
    sources of energy in 199
Air India, traffic and operating statistics of 284
air pollution, India 345
air quality, problem areas in India 346
air-borne emissions from industries 343
airport capacity augmentation, upgradation and improvement of 252
airport infrastructure, upgradation and improvement of 252
alternative chemicals as replacements for CFCs 398
alternative sources of energy, development of 16
aluminium companies, capacity, production, and capacity utilization of 229
aluminium consumption, growth of 222
aluminium industry
    in India, progress of 222
    installed capacity, production, and capacity utilization of 229
    limits for emissions of particulate matter from 367
aluminium production, energy use in 222
aluminium, specific energy consumption 230
ambient air quality levels in highly polluted cities 372
ambient air quality standards, establishment of 342
ambient air quality, monitoring of 345
ambient noise standards notified by CPCB 342
ammonia production, energy consumed in 221
ammonia, energy consumption of 228
animal species, recorded number of 417
Annex I carbon dioxide emissions and Kyoto Protocol proposals 436
annual demand for fuels 312
annual gross generation in utilities 124
annual plan expenditure during the Eighth Five-Year Plan and actual expenditure 59
anthropogenic emissions for 2100, SRES projections of 426
APM (administered pricing mechanism) 72
appropriate technologies, development and promotion of 160
area under high-yielding varieties 205
ATF (aviation turbine fuel) offtake 285
atmospheric carbon dioxide, reasons for increase in 403
atmospheric concentrations and anthropogenic emissions of carbon dioxide 399
Atomic Energy Commission (*see* AEC)
aviation turbine fuel (*see* ATF)

B

bagasse-based cogeneration 160
  potential for 177
basic research, strengthening of 2
BBMB (Bhakra-Beas Management Board) 9
biodiversity hotspots 415, 416
  identification of 391
biodiversity loss, underlying causes of 389
biodiversity
  climate change threat to 389
  India's rich heritage of 394
  intersectoral cooperation and mainstreaming of 393
  policy and institutional initiatives 395
biofuel use in the rural domestic sector 308
biofuels consumption in rural households 309
biogas development, national project on 192
biogas plants, installation of 168
biological diversity 388
  India's contributions to 323
biological resources, approaches to conserve 390
biomass burning, health hazards of 292
biomass energy in industry 168
biomass fuels to kerosene and LPG, switch from 288
biomass fuels use, human costs of 292
biomass gasifiers
  feasibility of utilizing 168
  installed number and capacity of 178
biomass power and cogeneration status 177
biomass power cogeneration projects, composition of 178
biomass-based power plants 161
Bio-medical Waste (Management and Handling) Rules 344
biomedical waste categories 371
Biosafety Clearinghouse, establishment of 393
biosphere reserves 395
  of India 419
Bonn agreement, key features of the 406
BOT (build-operate-transfer) projects, status of 267
BOVs (battery-operated vehicles), promotion of 172
brackish/sea water, desalination of 173
budget, fiscal incentives announced in 220
Buenos Aires Plan of Action, adoption of the 405
build-operate-transfer (*see* BOT)
buses owned by public and private sectors 264

C

calcium carbide plants, limits for emissions of particulate matter from 366
capacity addition envisaged in the Ninth Plan 108
capacity utilization in coking coal washeries 26
capital expenditure limit, amendments on 114
captive capacity and generation 125
captive coal mining, permission for 31
captive mining blocks allocation 44
carbon black industry, limits for emissions of particulates from 367
carbon dioxide emissions
  estimates for India 429
  from fuel combustion 404
carbon dioxide equivalent emissions in India 403
carbon dioxide fuel combustion emissions 434, 435
carbon dioxide mitigation options for India 437
carbon dioxide perturbations, annual budget of 432
carbon dioxide, global average temperature and atmospheric concentrations of 425
carbon emissions from fossil fuel burning 404
Cartagena Protocol on Biosafety 392
catalytic convertors, use of 247
caustic soda lye manufacturing, energy consumption for 242
caustic soda, processwise production of 241
CBD (Convention on Biological Diversity) role in policy development 393
CBD
  institutional structure of 392
  development of a strategic plan for 394
  implementation of 393
CDM (clean development mechanism) 405
  India's support to 407
CEA (Central Electricity Authority) 7
cement industry
  energy consumption of 224
  fuel consumption in 234
  growth of 233
  specific energy consumption in 235
cement plants
  energy-efficient technologies in 224
  limits for emissions of particulate matter 365
  status of 224
cement production, trends in 234
cement, per capita consumption of 224
Central Electricity Authority (*see* CEA)
Central Electricity Regulatory Commission (*see* CERC)
Central Inland Water Transport Corporation
  cargo carried by 273
  freight earned by 273
Central Mine Planning and Design Institute Ltd 10
Central Power Research Institute (*see* CPRI)
central temperature estimates 401
Centre for High Technology 11
CERC (Central Electricity Regulatory Commission) 9
  important orders issued by 112
cereal yields, expectation of decline 402
CFCs (chloroflurocarbons)
  annual production of 397
  decline in the manufacture and use of 396
change in energy consumption in the household sector 307
chlor-alkali industry
  energy-saving potential in 226
  installed capacity, production, and capacity utilization in 241
chlor-alkali, use of 225
chloroflurocarbons (*see* CFCs)
CIL (Coal India Ltd) 10
civil aviation, growth of 279
clean development mechanism (*see* CDM)
clean technologies, shift in approach 351

cleaner fuel quality in India 249
climate change impacts 401
climate change issues, India's efforts to address 407
climate change threat to biodiversity 389
climate change
  contributions to 17
  international negotiations on 405
  vulnerability of agricultural production to 402
CNG (compressed natural gas) activities in India 104
CNG pilot programme by GAIL 250
coal and coke, categorization of 46
coal and lignite sector at a glance 25
coal beneficiation 26
coal demand
  for the Ninth Five-Year Plan and actual production 29
  India 33
coal despatches of
  various companies 40
  various states 38
coal exploration and mining, legislative framework for 32
coal imports 30
  customs duty structure on 53
Coal India Ltd (*see* CIL)
coal industry, TERI's review of the regulatory framework in 31
coal movement 30
  inter-modal split of 50
coal pithead stock of
  various companies 41
  various states 39
coal prices, deregulation of 10, 32
coal production of
  various companies 40
  various states 37
coal quality 26, 347
coal reserves
  by category 34
  India 13, 25
  of states 34
coal royalty, revised rates of 53
coal sector reforms 31
coal sector, demand–supply scenario 29
coal supply to steel plants 61, 62
coal washeries, production from 47
coal
  annual average import price of 52
  ash content of 26
  availability and estimated sectorwise consumption of 60
  average cost of production of 51
  average pithead unit value of 51
  average pithead prices of 52
  demand estimates of 29
  improving the quality of 29
  lignite, and other derivatives, all-India production of 36
  net budgetary support 60
  production targets of 29
  royalty paid by states on 53
  sectoral offtake from CIL and SCCL 63
  selling price of 54
coalfields, location of 26
coastal infrastructure 403.
coastal shipping
  increase in share of 253
  development of 254
cogeneration projects, constraints in setting up of 160
coking and non-coking coal
  import 44
  production by companies and fields 42
coking coal washeries, capacity utilization in 26
combined land surface, air, and sea surface temperatures 400
commercial energy balance 19, 20, 21
commercial energy consumption
  in the domestic sector 306
  sectoral composition of 15
commercial fuels
  use in rural domestic sector 292
  shift in rural areas 291
Committee on Integrated Coal Policy 31
community involvement in conservation, necessity of 390
compressed natural gas (*see* CNG)
Conference of the Parties (*see* CoP)
conservation initiatives 394
conservation of mangroves and coral reefs 395
consumer's monthly per capita expenditure 298
containerization, promotion of 256
Convention on Biological Diversity (*see* CBD)
conversion efficiency of fuels used for cooking 306
CoP (Conference of the Parties)
  work on five thematic work programmes 392
copper, lead, and zinc smelting units, limits for emissions from 367
coral reefs, conservation and management of 395
countries with unusually high required migration rates 414
CPRI (Central Power Research Institute) 9
cross-subsidy from other users 144
crude oil and natural gas
  life of reserves for 83
  proven and balance recoverable reserves of 79
  reserve replacement ratio for 83
crude oil and petroleum products
  trade 86
  exports of 88
  imports of 87
  realization of excise and customs duties from 96
crude oil
  in India, recoverable reserves of 14
  production 81
  imports of 14
crude steel production
  by process 236
  specific energy consumption in 239
customs duty, revision of 74

D

DAE (Department of Atomic Energy) 11, 12
Damodar Valley Corporation (*see* DVC)
deaths averted due to Montreal Protocol, projections 397
deaths due to selected diseases 384
decentralized energy supply 162
deforestation and forest degradation in India, consequences of 323, 324
dense forest, open forest, and mangroves, assessment of 328
Department of Atomic Energy (*see* DAE) 11
deregulation of coal prices 10
DGH (Directorate General of Hydrocarbons) 10
DGH, setting up of 78
diesel and electric traction, energy consumed by 251
Directorate General of Hydrocarbons (*see* DGH)
distribution, private sector participation in 112
domestic sector
  at a glance 287
  commercial energy consumption in 306

domestic sewage, source of water pollution 349
downstream sector, organizations in the 11
draft agriculture policy, approaches of 200
Draft Battery (Management and Handling) Rules, 2000 345
drinking water standards for India, setting up of 342
dung cake consumption 291
durable products
  all-India purchases of 300
  purchases in rural area 301
DVC (Damodar Valley Corporation 9

E

EAFs (electric arc furnaces), electricity consumption in 225
ecological and conservation value, prioritizing areas of 391
ecoregions
  identification of 391
  selection of 391
effective subsidy and cross-subsidization 116
effluent standards for
  aluminium industry 359
  integrated iron and steel plants 359
  oil refinery industry 360
  petrochemical industry 361
  pulp and paper industries 360
  sugar industry 360
  thermal power plants 362
effluents from refineries 69
electric arc furnaces (*see* EAFs)
electrical appliances, purchase of 290
electricity consumption
  by agriculture sector 200
  in Indian EAFs 225
electricity generated, purchased, and consumed in steel plants 238
electricity generation
  increase in 107
  technologies through solar thermal route 170
electricity production and consumption 128
electricity regulation in India, framework for 7
electricity sector unbundling in different states 113
electricity
  average tariff for sale of 140
  average tariff of 139
  per capita consumption of 118
emission characteristics of vehicles, progress in improving 247
emission factors
  for different vehicles 368
  from cooking stoves 384
emission limits for
  diesel vehicles 368
  petrol-driven vehicles 368
emission norms for
  passenger cars 344
  petrol-driven vehicles 344
emission standards for polluting industries 343
emissions from
  domestic fuel consumption 348
  industries, standards for regulating 343
endemic species of
  animals 417
  plants 417
energy conservation in transport sector, strategy for 247
energy consumed by various modes of transport 246, 254
energy consumption
  efforts to reduce 225
  in fertilizer industry 228
  in India 13, 15
  in industry 227
  in rural and urban areas 307
  in rural households 291, 309
  in transport sector, reducing the 247
  of ammonia 228
  of fertilizer industry 221
energy consumption pattern
  in rural areas 291
  variations in 291
energy decisions, impacts on 4
energy demand
  dependence on 1
  nature of 1
energy demands in the
  rural domestic sector 290
  urban residential sector 289
energy exchange among the regions 109
energy imports, dependence on 15
energy intensity in India 13
energy prices, importance of 2
energy production and use, social dimensions of 17
energy production, trends in India 13
energy R&D investments in 1995 5
energy sector
  issues and concerns 15
  technology strategy for 5
energy sources
  in integrated steel plants 225
  to farm power, contribution of 211
  changes in 212
energy sub-sectors
  organizational framework in 7
  regulatory framework in 7
energy supply indicators 14
energy technology vision, development of 2
energy use disparity between rural and urban households 291
energy use implications for transport sector 5
energy use in the rural domestic sector 290
energy use patterns, health implications of 17
energy use per capita, high-income group 289
energy, impacts of technology on the availability of 2
energy-efficient technologies in cement plants 224
energy-related subjects in the Seventh Schedule 7
energy-use planning of transport sector 247
Engineers India Ltd 10
Environment Action Programme 340
environment at a glance 339
environment sector in India, organization of the 341
environmental clearance, projects requiring 354
environmental deterioration due to industrial production 16
environmental epidemiological studies 351
environmental health problems, urban dimension of 350
environmental impact assessments 351
environmental impacts of utilization of fuels 16
environmental legislation, acts, rules, notifications, and amendments 353

environmental management
  agencies related to 340
  decentralized structure for 351
environmental pollution, health problems caused by 350
environmental problems, major causes of 345
environment-related laws, increase in 351
ERC (Expenditure Reforms Commission), recommendations of 31
ETG (Expert Technical Group) recommendations, impacts of 73
ethanol-petrol, pilot projects on 250
Euro norms
  conforming to 343
  enforcement of the 344
Expenditure Reforms Commission (*see* ERC)
exploration and production of oil and gas, regulation of 77
exploration, private sector participation in 68

F

farm mechanization, progress in 199, 211
fertilizer industry
  energy consumption of 221, 228
  installed capacity, production, and capacity utilization in 227
fertilizer plants
  adaptation of natural gas 221
  limits for emissions from 366
Fertilizer Pricing Review Committee, recommendations of 221
fertilizers
  consumption of 209
  imports of 228
finished steel production by producer 236
firewood, share of 291
fiscal incentives announced in budget 220
fleet utilization 268
fly ash, problems due to the generation of 16
foodgrain production, increase in 198
foodgrains demand in 2030 200
foodgrains/commercial crops, procurement/support prices of 214
forest area
  expansion of 325
  India 322
forest cover, disparity in 322
forest degradation due to
  shifting cultivation 324
  wood extraction 324
forest fire 325
forest land, diversion of 325
forest produces, declining of 402
forest productivity, improvements in 325
forest products, efficient utilization of 325
forest resource of India, management of 322
forest resources
  depletion of 324
  pressure on 324
  protection of 325
forest types 322
forestry and logging, contribution to GDP 327
forestry sector, plan outline to improve 325
forests at a glance 321
forests in India, current status 322
forests
  changes in area under 336
  climate-induced changes 402
  economic services 321
  environmental services 321
  future scenario 336
  grazing in 335
  productivity of 329
  regeneration in 334
  role of 323
fossil fuel burning, carbon emissions from 404
fossil fuels
  production and use of 14
  use in energy combustion 17
framework for environmental legislation 339
freight and passenger traffic, Railways' share in 251
freshwater scarcity, reasons for 173
fuel combustion, carbon dioxide emissions from 404
fuel quality, improvement of 70
fuel-cell technologies
  application of 172
  development of 3
fuelwood availability 292
fuelwood consumption 291
fuelwood demand and total availability of land 331
fuelwood
  excess removal of 324
  requirement of 292

G

GAIL (Gas Authority of India Ltd) 10, 250
gas imports
  from Iran 74
  through pipelines 74
gas marketing by regional companies 11
gas prices 77
gas production in India 74
gas transmission and distribution network 77
gas transmission, infrastructure for 76
GDP (gross domestic product)
  in the transport sector 258
  contribution of forestry and logging to 327
  contribution of transport to 245
GEF (Global Environment Facility) projects in India 438
geothermal energy, utilization for power generation 172
GHG (greenhouse gas)
  and aerosol precursor emissions, scenarios of 400
GHG emissions
  from developed countries 430
  occurrence of 403
GHGs
  and ozone-depleting gases 422
  and their main characteristics 426
  over next 100 years, relative warming of current emissions of 400
global carbon dioxide emission estimates 429
global energy intensity 3
Global Energy Technology Strategy project 2
Global Environment Facility (*see* GEF)
global environment issues at a glance 387
global mean temperature change projections 401
global PV market, trends in 162
global sea-level change, projections 401
global stock of GHGs, responsibility of developed countries, 404
globally threatened species, assessment of 388
government R&D subsidies, efficient use of 3

- GPIs (grossly polluting industries) discharging into water courses 377
- grazing in forests 335
- *GREEN India 2047,* findings of 342
- greenhouse gas (*see* GHG)
- greenhouse solar still 173
- grid-connected power supply, applications in 163
- grid-interactive solar PV power projects 179
- gross domestic product (*see* GDP)
- grossly polluting industries (*see* GPIs)
- growth rates in major sectors of industry 220

H

- habitat loss, causes of 389
- hazardous waste generation
  - from the industrial sector 350
  - in India 383
- *Hazardous Wastes (Management and Handling) Amendment Rules, 2000* 344
- *Hazardous Wastes (Management and Handling) Rules, 1989* 344
- HDCs (high-density corridors) system, augmentation of capacity of the 251
- high speed diesel (*see* HSD)
- high-density corridors (*see* HDCs)
- highly-polluting industries, status of compliance by 347
- household consumption expenditure, shift in 291
- households
  - having electricity connection 299
  - using different fuels for cooking 314
  - using kerosene for cooking 293
  - using LPG for cooking 293
- HSD (high speed diesel), improving the quality of 70
- human health, impacts on 402
- hybrid systems, support by MNES 166
- hydro-electric power projects, potential and development of 130

I

- ICCP (Intergovernmental Committee for the Cartagena Protocol) on Biosafety 393
- India Country Programme, implementation of 398
- India
  - air pollution 345
  - coal reserves 25
  - demand for timber 323
  - energy consumption in 13, 15
  - energy intensity in 13
  - forest area 322
  - framework for electricity regulation 7
  - fuelwood consumption 323
  - installed generating capacity 14
  - lignite reserves 25
  - power scenario 117
  - rich heritage of biodiversity 394
  - trends in energy production 13
- India's biodiversity, protection of 394
- India's coal demand 33
- India's livestock population 216
- India's national GHG inventory for 1990 433
- Indian Airlines
  - physical performance of 281
  - traffic and operating statistics of 283
- Indian aluminium plants, performance parameters of 230
- Indian coal reserves 13
- Indian domestic sector, energy consumption patterns in 287
- Indian emission standards for thermal power plants 364
- Indian energy sector
  - institutional structure of 7
  - organization of 8
- Indian PV market segments 163
- Indian Railways, marketing strategies of 252
- Indian Renewable Energy Development Agency (*see* IREDA)
- Indian renewable energy programmes, global position of 176
- Indian shipping gross registered tonnage 272
- Indian vehicles, mass emission norms for 248
- India's contributions to biological diversity 323
- India's efforts to address the climate change issues 407
- Indo-Bangladesh protocol on inland water transit and trade 255
- indoor air pollution, significance of 350
- industrial effluent discharges, maximum permissible limits for 358
- industrial effluents, regulation of discharges of 343
- industrial energy consumption 220
- industrial environmental problems 345
- industrial growth, slowdown of 220
- industrial pollution, share of 349
- industrial production, environmental deterioration due to 16
- industrial sector, hazardous waste generation from 350
- industrial wood
  - demand–supply situation of 332
  - scenario of 336
- industries' share in water pollution 349
- industry at a glance 219
- ingot steel, production of 236
- inland surface water, criteria for classification of 357
- inland water transport (*see* IWT)
- inland waterways with ports, linking 255
- installed capacity 120
  - and refinery crude throughput 84
  - in selected industries 127
  - of utilities by region and state 122
- installed generating capacity of India 14
- installed power generation capacity 347
- installed refining capacity 69
- integrated iron and steel plants
  - effluent standards for 359
  - permissible limits for emissions 365
- integrated steel plants, energy sources in 225
- Intergovernmental Committee for the Cartagena Protocol (*see* ICCP)
- international negotiations on climate change 405
- international petroleum statistics 102, 103
- IPCC Third Assessment Report on climate change 399, 400
- IREDA (Indian Renewable Energy Development Agency) 11, 160
  - revolving fund for RETs 163
- iron and steel industry, energy consumption 224
- irrigated area
  - by sources 209
  - under selected crops 208
- irrigation potential, development of 207

IWT (inland water transport)
  efficiency of 254
  enhancement of safety and reliability 255
  reduction in cost and time of transportation 255
  share in the total transport network 254

J

joint ventures, establishment of 32

K

kerosene consumption in India 293
kerosene supply
  during 2000/01 294
  through PDS, steps involved in 293
kerosene, allocation and distribution of 293
Kyoto Protocol
  adoption of the 405
  main features of the 406
  operational details for implementing 407

L

land-use classification 202
lignite reserves of states and union territories 35
lignite reserves, India 25
liquefaction facility in Iran 76
liquefied natural gas (*see* LNG)
liquefied petroleum gas (*see* LPG)
Liquid Fuel Policy, modification of the 114
LNG (liquefied natural gas) imports, projects envisaging 76
LNG project
  at Gopalpur 76
  under Dabhol Power Project 75
LNG terminal at
  Dahej 76
  Ennore 76
  Hazira 76
  Kakinada 76
  Kochi 76
  Pipavav 76
  Trombay 76
loss in farm-level net revenue 402
low-sulphur diesel, introduction of 344
LPG (liquefied petroleum gas) availability, increase in 295
LPG consumption 294
LPG marketing 294
LPG subsidy 294

M

major ports
  capacity available at 274
  cargo traffic handled at 275
management and handling of hazardous wastes, guidelines for 344
management of mangroves and coral reefs 395
mangroves, conservation and management of 395
market information surveys of households (*see* MISH)
mass emission norms 343
mass emission standards for
  diesel-driven vehicles 370
  petrol-driven vehicles 369
membrane cell process 226
mercury cells 226
methane, estimated sources and sinks of 432
minimum stack heights, guidelines for 363
mining technology, shift in 30
mining waste in the mechanized opencast mines 383
Ministry of Coal (*see* MoC)
Ministry of Non-conventional Energy Sources (*see* MNES)
Ministry of Petroleum and Natural Gas (*see* MoPNG)
Ministry of Power (*see* MoP)
minor ports, cargo traffic handled at 276
MISH (market information surveys of households) 290
MNES (Ministry of Non-conventional Energy Sources) 11
MoC (Ministry of Coal) 10
monthly average spot quotations for Dubai crude oil 74
monthly per capita consumption 289
monthly per capita expenditure (*see* MPCE)
monthly per capita fuel consumption 291
Montreal Protocol
  adoption of 396
  amendments to 396
  policy decisions to meet India's commitments 398
MoP (Ministry of Power) 7
MoPNG (Ministry of Petroleum and Natural Gas) 10
mortality, causes of 350
motor vehicle accidents in metropolitan cities 269
motor vehicles, growth in the number of 247
MPCE (monthly per capita expenditure)
  on fuel and light in rural areas 289
  on fuel and light in urban areas 289
MSW (municipal solid waste), increasing of 350
MSW characteristics on weight basis 380, 381
MSW generation 379
MSW management 350
  in selected metro cities 382
MSW treatment and disposal in metro cities 382
multimodal transport
  encouragement of 252
  importance of 255
  problems faced by 255
municipal solid waste (*see* MSW)
Municipal Wastes (Management and Handling) Rules, 2000 345

N

NAAQS (National ambient air quality standards) 342, 355
National Biomass Gasifier Programme 168
national carriers
  domestic and operating statistics of 282
  domestic passenger traffic 281
  statement of scheduled services of 280
National Conservation Strategy and Policy Statement on Environment and Development 340
National Council for Applied Economic Research (*see* NCAER)
National Council for Environmental Policy and Planning 340
National Forestry Action Programme – India, broad thrust areas of 325
national highways, total and surfaced length of 265
National Hydroelectric Power Corporation (*see* NHPC)
national parks, financial assistance to 395

National Programme on Improved Chulhas 168
  achievements under 193
National Thermal Power Corporation (*see* NTPC)
natural gas demand 74
natural gas offtake by industry 75, 94
natural gas prices, increase in 77
natural gas production 82
natural gas
  adaptation in fertilizer plants 221
  consumer prices of 100
  reserves of 14
natural vegetation change since establishment of tropical parks 390
NBSAP (National Biodiversity Strategy and Action Plan), implementation of 393
NCAER (National Council for Applied Economic Research), study by the 169
NELP (New Exploration Licensing Policy)
  features of 68
  blocks on offer under 69
  first round of 68
  second round of 68
New Exploration Licensing Policy (*see* NELP)
Neyveli Lignite Corporation (*see* NLC)
NHPC (National Hydroelectric Power Corporation) 9
Ninth Five-Year Plan, objectives of 342
nitrogen oxides sources 403
nitrogenous fertilizer plants, capacity utilization of 221
NLC (Neyveli Lignite Corporation) 10
noise levels in metropolitan cities 374
noise standards 356
non-coking coal, comparison of gross calorific value and useful heat value for 47
non-conventional energy, capacity addition of various sources of 176
non-renewable resources, pricing of 159
non-wood forest products (*see* NWFPs)
NTPC (National Thermal Power Corporation) 9
Nuclear Power Corporation of India Ltd 12
nuclear power projects, details of 129
number of consumers and connected load 148
NWFPs (non-wood forest products), dependence on 323

O

OCC (Oil Coordination Committee) 10, 78
  key functions of 78
ocean energy 172
ODP (ozone-depleting potential) demand up to 2010 398
ODS (ozone-depleting substances) consumption in India 398
ODS production for India 424
ODS, regulation on production and consumption of 399
OIL (Oil India Ltd) 10
  exploratory and development drilling by 80
oil and gas production 68
oil and gas sector, at a glance 67
oil and gas
  exploration and production 67
  regulation of exploration and production of 77
Oil and Natural Gas Corporation Ltd (*see* ONGC)
Oil Coordination Committee (*see* OCC)
Oil India Ltd (*see* OIL)
Oil Industry Development Board 10
Oil Industry Safety Directorate 10
Oil Pool Account, creation of 72
oil prices 73
  bases of 72
oily sludge, management of 70
ONGC (Oil and Natural Gas Corporation) Ltd 10
  exploratory and development drilling by 80
OPEC (Organization of the Petroleum Exporting Countries)
  crudes, spot prices of 95
opencast and underground mining, OMS (Output per man-shift) in 45
opencast mining, increase in the level of 30
organizational framework in energy sub-sectors 7
outlay expenditure in public sector, all-India pattern 217
over-extraction of green fodder, cause of forest degradation 325
overgrazing, cause of forest degradation 325
Ozone Depleting Substances (Regulation and Control) Rules, 2000 399
ozone depletion, international cooperation on 397
ozone losses with and without the Montreal Protocol, projection of 397
ozone-depleted atmosphere, increase of 396
ozone-depleting potential (*see* ODP)
ozone-depleting substances (*see* ODS)

P

PA (protected areas), condition of 390
paper industry
  installed capacity, production, and capacity utilization in 239
  specific energy consumption in 240
per capita annual consumption of selected fuels 289
per capita carbon dioxide emissions 404
per capita consumption of
  electricity 118
  power 107
per capita fuel consumption in
  rural areas 310
  urban areas 310
performance of total rainfall 206
pesticides
  adverse impacts of 349
  consumption of 210
petrol and diesel specifications for 2005 250
petroleum and natural gas
  actual expenditure of 101
  Eighth Plan outlay of 101
Petroleum India International 11
petroleum products handled at major ports 89
petroleum products
  consumption of 70, 92
  development of basic ceiling prices of 97
  growth rates of consumption of 91
  imports of 14

oleum products *continued*
  marketing and distribution of 70
  movement by railways 89
  production of 85
  product-wise sales of 71
  refinery crude throughput and production of 84
  retail selling price of 98
  sales/consumption of 90
  subsidies on 94
  transportation of 71
oleum sector, establishment of a
gulatory authority for 78
oleum, oil, and lubricants (*see*
OL)
(Power Finance Corporation) 9
IL (Power Grid Corporation of
dia Ltd) 9
sphatic fertilizer plants, energy
onsumption of 229
tovoltaic (*see* PV)
t-phase activities of projects
nplemented jointly 439
line from Bangladesh 75
lines infrastructure, develop-
ent of 71
expenditure and the share of
oal and total energy 58
t load factor (*see* PLF)
t species, declining of 388
t species, recorded number of 416
(plant load factor)
  India 109
  of thermal stations 123
  of central and state sector stations 109
L (petroleum, oil, and lubricants)
onsumption in transport 259
cy and institutional framework,
trengthening of 325
cy framework, development of 340
cy initiatives
  announced in Budget 2000/01 219
  adoption of 253
cy Statement for Abatement of
ollution, 1992 340, 351
lutants emissions from vehicles in
etropolitan cities 348
lutants
  due to biofuels burning 385
  from cooking stoves, impacts of 350
luted cities, ambient air quality
evels in 372
luted river stretches in India 376
polluting vehicles, phasing out of 250
pollution and depletion of resources, impact of 350
pollution contract status in industries 375
pollution control status of industries 374
pollution issues, addressing at national level 340
pollution levels, monitoring and regulating of 342
pollution sources of rivers 349
pollution, industrial contribution to 347
population under different MPCE (monthly per capita expenditure) classes 288
port capacity, need to augment 253
port infrastructure
  for crude oil and petroleum products 72
  upgradation of 254
ports handling oil, categorization of 72
ports
  commodity traffic at 277
  restructuring of 253
  traffic handled by 253
potable water quality standards recommended by WHO 378
potential hydroelectric power projects 130
Power Finance Corporation (*see* PFC)
power generating entities 164
power generation 160
Power Grid Corporation of India Ltd (*see* PGCIL)
Power Ministers' Conference, resolutions at 115
power sale to consumer by category 154
power scenario in India 117
power sector at a glance 107
power sector developments during 2000/01 108
power sector outlay, distribution of 119
power sector reforms, speeding up of 112
power sector
  greater investments in 110
  improvements in 110
  overview of 107
  plan outlay and expenditure for 155
power supply, unit cost of 138
power system, demarcation into five regions 108
Power Trading Corporation of India Ltd (*see* PTC)
power
  captive capacity 109
  demand projections 109
prices of energy products, increase in 290
primary commercial energy flows 1
principal crops
  area under 203
  production and yield of 204
private distribution companies 114
private power projects identified for implementation during Ninth Plan 157
private sector participation 110
private sector participation
  in distribution 112
  in exploration 68
  in generation 112
  areas of 253
  needs of 32
private sector projects commissioned 156
private sector/captive port projects 278
process of tariff setting, transparency in the 114
product storage and movement 89
production and use of energy, social dimensions of 17
production function, inputs for 1
productivity of forests, deterioration in 323
productivity, improvement in 30
programmes during the Ninth Plan, progress in 177
project on development of high rate biomethanation processes, achievements of 167
Project Tiger reserves 421
projections for energy demand for cooking 311
  and lighting 311
projects for energy recovery from rural and industrial wastes 167
proposed product pipelines by the PIL (Petronet India Ltd) 72
proposed World Bank emission guidelines for thermal power plants 364
protected areas in India 420
PTC (Power Trading Corporation of India Ltd) 9, 115

pulp and paper industry
    capacity utilization in 225
    energy consumption in 225
    product range of 225
    specific energy consumption norms for 240
pump-sets energized, number of 213
pump-sets, energization of 135
purchase of power by major sources 126
PV (photovoltaic) technology 161
PV in India, applications of 163
PV market segmentation 162
PV modules, manufacturers of 162
PV systems, uses of 161
PV technology, applications of 162
PVs
    growth of 162
    barriers to the deployment of 161
    characteristic features of 161
    production in India 162

R

radiative forcing, contribution of different sectors to change in 403
rail to road in freight traffic, shift from 251
rail transport system, modernization and upgradation of 252
railway routes and tracks, electrification of 270
railway traffic 270
Railways' share in freight and passenger traffic 251
railways
    delay in development projects by 251
    energy intensity in 271
    privatization of services 252
rate of return of SEBs (state electricity boards) 115
raw coal feed and clean coal production of washeries 48
REC (Rural Electrification Corporation) 9
Recycled Plastics Manufacture and Usage Rules, 1999 345
reef formations in India 395
regeneration in forests 334
registered motor vehicles 262, 263
regulation of
    electricity in India, framework for 7
    exploration and production of oil and gas 77
regulatory authority for the petroleum sector, establishment of 78
regulatory framework in energy subsectors 7
renewable energy potential and achievements in India 176
renewable energy sources and technologies at a glance 159
renewable energy technologies (*see* RETs)
renewable-energy-based desalination systems, classification of 173
renewables
    barriers in the propagation of 174
    contribution of 160
RETREAT (Resource Efficient TERI Retreat for Environment Awareness and Training) 172
RETs (renewable energy technologies)
    applications of 160, 175
    development of 175
    expanding the use of 15
    innovations in 4
    revolving fund from IREDA 163
rivers, pollution sources of 349
road accidents 268
road length
    by category 264
    in relation to area and population 266
road sector, commercialization of 251
road transport operation, improving the 251
road transport, increase in 246
road-based passenger transport, growth of 246
royalty paid on coal by states 53
rural and urban households
    by fuel used 301
    energy use disparity between 291
    source of energy for lighting in 313
rural areas
    consumption of fuel in 304
    energy consumption pattern 291
rural domestic sector
    commercial fuels use in 292
    energy demands in 290
    energy use in 290
Rural Electrification Corporation (*see* REC)
Rural Electrification Programme 292
rural electrification
    government's commitment to 162
    progress in 136
rural households
    by primary source of energy for cooking 302
    distribution by primary source of energy 315, 316
    using primary fuel for cooking 288
    demand for heating energy in 313
    likely pattern of fuel use in 313

S

sales revenue as a ratio of cost 146
salt-gradient solar ponds, relevance of 171
SCCL (Singareni Collieries Company Ltd) 10
SEBs (state electricity boards)
    rate of return of 115
    commercial profit/loss for 149, 150
    cost structure of 137
    rate of return on capital 151, 152, 153
    retail tariff of 116
    revenue arrears receivable by 141
sectoral energy consumption by fuel 15
SERCs (state electricity regulatory commissions) 9
Seventh Schedule, energy-related subjects in 7
SHP (small hydropower) potential in India 166
SHP capacity 167
SHP generation, importance of 166
Singareni Collieries Company Ltd (*see* SCCL)
small hydro potential capacity 190
small hydropower (*see* SHP)
smelters, energy-saving options in 222
SNAs (state nodal agencies), responsibility of 11
soda ash industry, specific energy consumption in 242
soda ash manufacturing process, main steps in 226
solar air-heating systems 171
solar architecture 171
solar cooker, world's biggest 170
solar cookers
    many types of 170
    parabolic dish type 170
    Scheffler 170

- solar energy
  - for industrial applications 169
  - benefits of 171
  - cooking with 170
- solar membrane distillation system 174
- solar PACES programme 170
- solar passive system developed by TERI 172
- solar pond at Kachchh Dairy, Bhuj 171
- solar pond desalination systems 173
- solar PV–electrodialysis 174
- solar PV technology, development of 4
- solar stills 173
- solar thermal energy, utilization of 169
- solar thermal power generation plants, stand-alone mode 171
- solar thermal technologies for electricity generation 170
- solar water heating systems 169
- solar-based building designs, promotion of 172
- solar-powered reverse osmosis 174
- Special Report on Emission Scenarios (*see* SRES)
- species extinction, causes of 388
- speed differentials, reducing of 251
- sponge iron plants, energy consumption per tonne in 238
- sponge iron production by producer 237
- SPV, dependence on natural resources 166
- SRES (Special Report on Emission Scenarios) 400
- state electricity boards (*see* SEBs)
- state electricity regulatory commissions (*see* SERCs)
- state nodal agencies (*see* SNAs)
- state of the environment, disturbance to the 16
- statewise annual biofuel consumption 330
- statewise annual fuelwood availability 330
- status category summary by major taxonomic group
  - (animals) 412
  - (plants) 413
- status of
  - PPPs (private power projects) 110
  - reforms in states 112
- strategic plan, main purpose of 394
- stratospheric ozone depletion, problem of 396
- subsidy
  - for agricultural consumers 142
  - for domestic consumers 143
  - to sales revenue ratio 145
- sulphur dioxide emissions, control of 70
- sulphur dioxide from oil refineries, limits for emissions from 366

T

- T&D (transmission and distribution) lines, length of 132
- T&D losses assessment in the states 110
- T&D losses in state electricity departments 131
- T&D network
  - increase in 108
  - growth of 109
- technical-grade pesticides, production and consumption of 209
- technology impacts on the availability of energy 2
- technology strategy for the energy sector 5
- technology upgradation fund (*see* TUF)
- technology
  - definition of 1
  - status of 1
- Tenth Five-year Plan, draft approach paper 250, 252
- TERI, commissioning by the Ministry of Coal 31
- TERI's review of the regulatory framework in the coal industry 31
- TERI's solar passive system 172
- textile industry
  - energy consumption in 223, 232
  - energy intensity of 232
  - energy saving opportunities in 223
  - production by 231
- textile mills
  - electricity consumption in 233
  - power consumption in 232
- *The Essential Commodities Act, 1955* 77
- *The Oilfields (Regulation and Development) Act, 1948* 77
- *The Petroleum Act, 1934* 77
- *The Petroleum and Natural Gas Rules, 1959* 77
- thermal energy consumption 224
- thermal energy requirements in the Indian industrial sector 169
- thermal power stations, limits of particulate matter emissions from 362
- threatened animals of India 419
- threatened species of India 418
- timetable of reductions from baseline levels 423
- towns electrified, number of 136
- traditional fuels, over-dependence on 292
- transmission and distribution (*see* T&D)
- transport fuel quality in India 249
- transport infrastructure, crude oil 71
- transport sector
  - at a glance 245
  - GDP in the 258
  - implications for energy use 5
  - private sector participation in 253
  - problems in the development of 253
  - share in the GDP of 245
  - strategy for the conservation of energy in 247
- transport
  - energy consumed by 254
  - energy consumption by mode of 246
  - energy intensity of various modes of 245
  - key data on 260
  - POL consumption in 259
- travel demand, increase in 246
- trends in relative rail and road traffic 272
- tropical forests and grasslands, dieback of 402
- tropical parks, change in natural vegetation since establishment of 390
- TUF (technology upgradation fund), need for 223

U

- UNDP/GEF technical assistance project 167
- unit cost of supply recovered from the consumer tariff 147
- urban and industrial waste projects 191
- urban areas, consumption of fuel in 305

- urban households distribution by primary source of energy 317, 318
- urban households
  - annual consumption of fuels by 312
  - by primary source of energy for cooking 303
  - using primary fuel for cooking 288
- urban municipal and industrial wastes 190
- urban poor, dependence on biofuels of 290
- urban population and settlements in India 297
- urban residential sector, energy demands in the 289
- urban transport, major problems of 247
- US power plants, size of 4
- UV-B radiation, consequences for human and ecological health 396

V

- vehicular emission standards
  - setting up of 343
  - in India, tightening of 247
- vehicular pollution
  - in urban areas 343
  - factors attributable to 348
  - problems of 348
- villages electrified and rural population benefitted by electricity 134

W

- waste management technologies, importance of 167
- waste water collection and disposal, problem of 349
- water contamination, types and sources of 348
- water pollution 348
  - share of industries 349
- water pollution source, domestic sewage 349
- water pumping windmills, statewise installation of 166
- water quality in surface water bodies 343
- water supply, scarcity of 172
- waterways, development of 255
- WHO (World Health Organization) guidelines values for air pollutants 356
- wild relatives of crops and medicinal plants 418
- wind battery chargers/aerogenerators 164
- wind energy monitoring and resource assessment programme, India 164
- wind energy potential and possible installed capacities 188, 189
- wind generators, dependence on natural resources 166
- wind monitoring stations in India 182, 183
- wind power installed capacity 180
  - in India 164
- wind power projects
  - in India 181
  - bilateral finance assistance to 164
  - financing by national finance institutions 164
  - multilateral finance assistance to 164
  - total generation from 180
- wind pump models, development of 165
- wind pumps, subsidy on 165
- wind-powered electrodialysis 174
- wind-powered reverse osmosis 174
- wind–SPV hybrid systems 166
- wood consumption 335
- wood extraction from forests, cause of forest degradation 324
- wood/timber, demand and availability of 333
- woodfuels in India, sources of supply of 332
- World Health Organization (*see* WHO)
- World Heritage sites of India 419

Our team produces more than half of all Wind Power. But that isn't why our clients return for more.

The Power within.

Excellence is performance consistently bested Team effort has a power within to achieve a sum greater than its individual member's potential. To push possibilities And win excellence at an everyday level.

Clients throw challenges. Team effort sees them through. Our first installation for IPCL came with a stiff deadline. Our team rose to the challenge. It set the benchmark of on-time commissioning for every project we took up since then.

Often innovation will show the way. For instance, we fine tune wind electric converters to leverage local wind resources and harness every potential unit of power. We overcome site-specific constraints and infrastructure hurdles with new logistic solutions: modifying cranes to lift very heavy machinery to 60 m heights; widening narrow mountainous curves to transport blades (30 meters) longer than a ten storied building; or even helping local utilities create evacuation facilities where none exist.

The End of a sale. The Beginning of total responsibility. Clients don't buy just wind power They buy assured return on investment and peace of mind. We provide total power solution. Handling every little detail from machine installation to commissioning to day to day monitoring and 24 hour after sale support. Moreover, a dedicated on-site team administers preventive maintenance. Which is why Suzlon wind electric converters yield over 20 years of productive life with optimized performance and higher machine availability. While our clients enjoy minimum response times and maximum ROIs.

Records happen once in while. Excellence is achieved each day. Wind Farming is a specialist's job. Our team's considerable experience and know-how are proven in projects of every scale (World's largest Wind Power Park of its kind, is a case in point). The best of international expertise are chosen to ensure peak operational performance. While worldwide Research & Development leverages the latest technological breakthroughs. Such proficiency at every level helps us optimize capital deployed to output ratio to unprecedented levels.

Suzlon is Asia's leading Wind Power Company and world's top ten in the field. But it is the total commitment behind our path-breaking performance that our clients really value. And return for more.

SUZLON

SUZLON ENERGY LIMITED
Powering a Greener Tomorrow

Corporate Office: Godrej Millennium, 9 Koregaon Park, Pune-1, Ph 020 4022000. Fax . 020 4015759 Email tgirish@suzlon.com